The Engineer

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The Engineer

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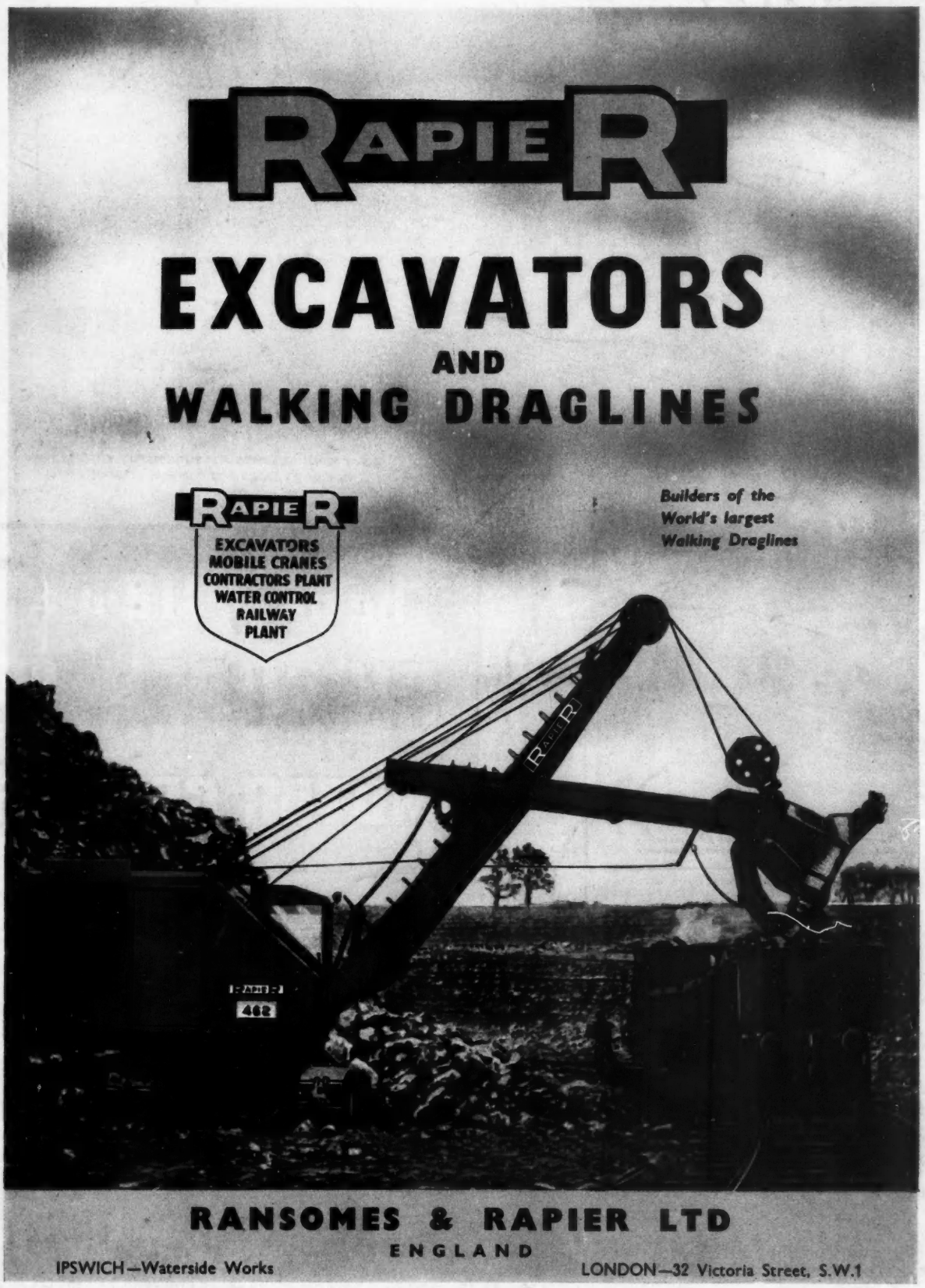

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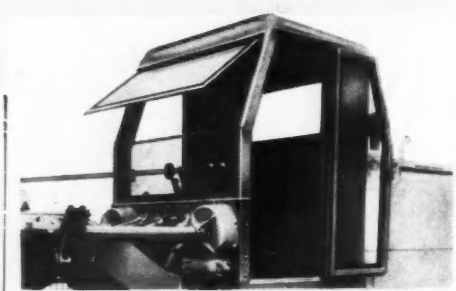

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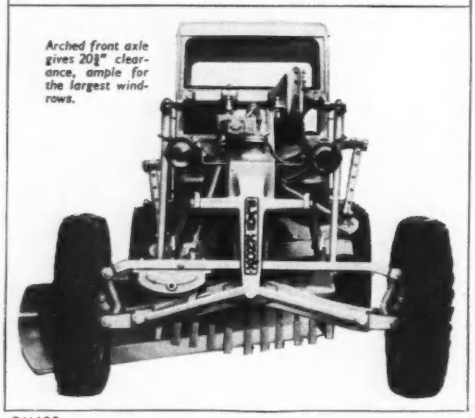

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THE ENGINEER

JANUARY 7, 1955

Public School and Grammar School Boys in Industry

THE Federation of British Industries has published a booklet entitled "Public School and Grammar School Boys in Industry." It suggests that industry is in danger of neglecting the public schools and grammar schools as a source of potential managerial talent and proposes a simple scheme for providing careers advisers with information in a handy form about the prospects in industry. The booklet points out that as a result of educational changes since the war, many more grammar school boys remain at school until they are seventeen or eighteen, as the public school boy normally does. The experience they gain in the sixth form is of great value in developing personal qualities such as leadership and a sense of responsibility. In the past, industry could be sure that the boys it recruited from the elementary schools at thirteen or fourteen would include a number who possessed the brains and personality to develop later into foremen, departmental superintendents, works managers and even directors. In those days, the number of boys who went to grammar schools was relatively small and probably very few of them entered industry. The Education Act of 1944, however, placed great emphasis on selection at the age of eleven for the different kinds of secondary education—grammar, modern and technical—and to-day the proportion of boys educated in secondary grammar schools is 17 per cent of the total number in the secondary schools as a whole, compared with 11·5 per cent in 1938. The booklet says that although the selection procedure is criticised from time to time, it nevertheless appears to be reasonably effective, and that broadly speaking the best intellectual talent in the secondary schools of England and Wales is to be found in the grammar schools. The same applies in Scotland, where the equivalent is the senior secondary school. At present, 18 per cent of the grammar school boys leave at fifteen, 48 per cent at sixteen and 34 per cent between seventeen and nineteen. A large proportion of them are therefore available for recruitment at an age when industry is in direct competition with the Civil Service and other professions. The same is true of the public school boy. The booklet goes on to suggest that, as schoolmasters in general are less familiar with the prospects in industry, firms which can offer training and posts suitable for public school and grammar school boys should summarise this information on a standard index card and arrange for cards to be distributed to the appropriate schools. Detailed suggestions are made for distribution, in which the Central Youth Employment Executive and the Public Schools Appointments Bureau have undertaken to co-operate.

Factory Accidents

THE annual report of the Chief Inspector of Factories, Sir George Barnett, was published by H.M. Stationery Office at the end of last week. It covers the year 1953 and says that for the first time since the war there was an appreciable increase in the number of accidents, although the total was below the 1951 figure. The total number of accidents in 1953 was 181,637, compared with 177,510 in 1952, an increase of 2·33 per cent. But there was a drop in the number of fatal accidents from 796 in 1952 to 744 in 1953. The report notes that in the year 1953 the accident rate per 1000 workers in factories only was 22·7, compared with 22·5 in 1952 and 23·4 in 1951, indicating that accidents had increased more than proportionately to the working population. The general picture, except in the metal trades, in which there was a 7 per cent reduction in accidents, was of increased personnel and a somewhat more proportional increase in accidents owing mainly to the greater number of man-hours worked. The chief inspector comments on particular classes of accident, and on the incidence of accidents to young and elderly workers. In the report, dissatisfaction is expressed at the continuing high incidence of accidents on woodworking machinery, a matter which, the chief inspector says, demands the serious consideration of managements and operatives. Concern is also expressed over the number of serious accidents which occurred during the year at belt conveyors. Nevertheless, the report records improvement of accident prevention organisation. Sometimes, it is remarked, this had been under the regrettable stimulus of serious accidents and prosecutions, but gradually there has been achieved a great deal by progressive managements, keen safety officers, active works committees, and by the inspiration of the Royal Society for the Prevention of Accidents. Separate sections of the report are devoted to accidents in foundries, building operations, engineering construction works, and the installation of plant. There is also a chapter in the report on the general subject of industrial health.

European Coal and Steel Community

THE European Coal and Steel Community has now published a report by its High Authority which was recently submitted to an extraordinary session of the Common Assembly. The report deals mainly with the progress of the Community up to November last. It points out that the establishment of the common market for coal, iron ore, scrap and steel is a continuous process, and is not merely a matter of eliminating import and export quotas. It involves also doing away with customs duties and currency restrictions, matters which, the report comments, have been in progress ever since the common market was introduced in 1953. About the establishment of a coal policy, the report says that the High Authority must see to it that there is a regular flow of supplies to the common market, and that conditions are established "which will ensure the continuous development of production without unjustified measures against competing industries." The report goes on to comment that the relationship between the dependability of natural resources and the availability of increasingly economical supplies is particularly difficult to achieve under the conditions governing the production of coal in Europe. New production capacity can be developed only by means of very long-term investments, and there is the danger, the report observes, that installations which are closed down are likely to be a permanent loss. In formulating a coal policy, the report asserts, the High Authority must see to it that research into the development of medium and long-term requirements is continued and regularly brought up to date. It must also investigate the conditions of competition between coal produced in the Community on the one hand, and coal from third countries and other sources of energy, on the other. The formulation of a satisfactory coal policy also depends, the report adds, on the evaluation of the possibilities of assured supplies from other sources of energy, whether imports or oil products, and the possible consequences of technical development on the division of consumption between coal and oil.

National Boat Show

ON Thursday morning of last week the first National Boat Show, organised by the Ship and Boat Builders' National Federation, was opened in the Empire Hall at Olympia, London, by Coxswain H. Bradford of the Exmouth lifeboat. More than sixty boats are on view, ranging from the small dinghy to the large sailing yacht and motor cruiser, all representative of the boat builder's art, together with numbers of engines and examples of ancillary equipment. The oldest boat in the show is the Queen's Shallop or State Barge, which was built in 1689, to the order of William III, as a gift for Queen Mary, and remained in continuous use for State occasions until 1920. In contrast with the old is a racing eight for Magdalen College, Oxford, built of reinforced plastics, and boats of this material are exhibited on several stands. Racing yachts are well represented and include the Duke of Edinburgh's "Coweslip," and there are several examples of seagoing cruising yachts with a variety of rigs, and also a selection of sailing dinghies. A number of power-driven craft are on view and include launches, motor cruisers suitable for quiet inland waterways or more strongly constructed for open sea work, and fast runabouts, some of which are clinker built or of moulded plywood or aluminium alloy construction. A section of the exhibition of particular interest is that devoted to craft costing under £250, and the adjacent stand which takes the form of a "build-it-yourself" boatyard. All three services, the Royal Navy, the Army and the Royal Air Force, are represented and there are large numbers of models of various small craft on view. There are a number of stands which display outboard motors and petrol and diesel engines, which are designed to suit a wide range of propulsive requirements. In addition to the boats and engines, the show includes an extensive display of auxiliary machinery, deck fittings, cooking and heating gear, and other items forming part of a boat's outfit. There are demonstrations of the Aqualung and a gallery in which members of the Society of Marine Artists are exhibiting pictures of marine subjects.

Replacement of Lost Capacity in the Coal Mining Industry

IN the "Fuel Economy Review, 1955," just published by the Federation of British Industries, there is an interesting article by Sir Hubert Houldsworth, the chairman of the National Coal Board, entitled "Replacing Lost Capacity: the Constant Problem of the Coal Mining Industry." This article answers the question as to why this country's mines cannot now produce 240 million tons of coal a year as they did in 1937. It points out that the industry of 1937 no longer exists as, since then, 3500 million tons of coal have been extracted since then. Where the same seams are being worked the coal face tends to be further away from the shaft; and where different seams are being worked, because the old ones have been exhausted, they are often thinner and more difficult to work. In addition, some pits have reached the end of their workable resources. For the ten years following the inter-war peak period—of which seven were war years—very little fundamental development work took place. It is estimated that in that time the industry's capacity declined by about 50,000,000 tons—somewhat less than the decline in output. Dealing with future prospects, Sir Hubert says that in the next ten years if nothing is done to replace the annual loss of capacity there may be a further drop of 4,000,000 to 5,000,000 tons of coal a year. He goes on to deal with the National Coal Board's proposals which were formulated and summarised in "Plan for Coal," published in 1950. These proposals for the development of the coal industry up to the period 1961–65 aim at producing an annual output of about 240 million tons by the end of that period. To achieve this more than 250 collieries were to be reconstructed to yield nearly 70 per cent of all the coal required; a score of large new collieries and a number of new drift mines would probably account for another 10 per cent; and the remaining 20 per cent would come from some 250 collieries continuing in their present state without major reorganisation.

The Royal Navy in 1954

BY OUR NAVAL CORRESPONDENT

No. I

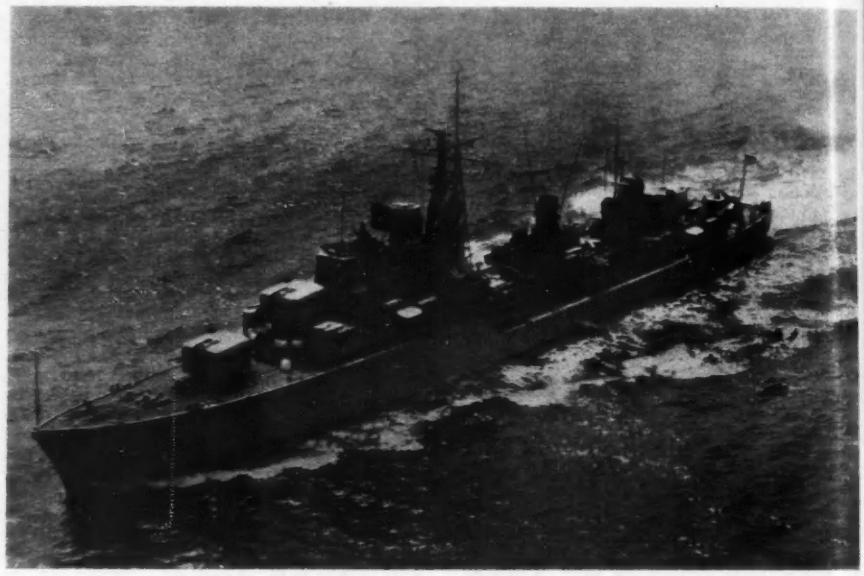
The Naval Situation To-day

LAST August the Admiralty gave an estimate of the strength of the Soviet Navy in 1957—the year when, it may be assumed, the ships provided for under our original three-year naval rearmament programme begun in 1951 will all be completed. By then the Russians are expected to have thirty cruisers, 150 destroyers, 500 submarines, 4000 naval aircraft and 1000 minesweepers, in addition to many hundreds of escort vessels, patrol and other small craft. Nearly all the vessels are of post-war construction and most of the aircraft are jets. Some £12,000 million appears to have been spent on the Soviet Navy since 1945, which—having regard also to the Soviet expenditure on an army and air force of 175 divisions, 60,000 tanks and 20,000 aircraft—lends support to the view that Russia does not intend to be the first to use nuclear weapons. A comparison of the strength of the Royal Navy and the Soviet Navy presents a truly alarming picture. Apart from the Soviet Navy's immense force of submarines and naval aircraft—most of which are capable of laying mines—the Royal Navy is now greatly inferior in both cruisers and destroyers. Russia, it is true, has no battleships or carriers but these vessels are not required unless she intends to dispute the control of the sea communications. Since the war we have not laid down one fighting ship larger than a frigate, having concentrated our naval effort on building vessels to deal with fast submarines and new kinds of magnetic and influence mines. This has resulted in the Royal Navy now being left with only twenty-three ageing cruisers—none of which has a gun larger than 6in, compared with the 7·1in guns in many of the Soviet cruisers—eight recently completed, powerful destroyers, now called "Daring" class ships, and sixty-five other reasonably modern destroyers.

As a member nation of N.A.T.O., this country, it must be recognised, has done her full share since 1951 in meeting N.A.T.O.'s most urgent needs. Faced with the necessity of building up a large army and air force in Western Europe, we shall have completed by 1956 or 1957 six carriers laid down in the war, in addition to modernising and reconstructing another and the eight "Daring" class ships, which were also part of the war-time programme. And our anti-submarine and mine sweeping forces will have been reinforced by the following vessels: seventy fast frigates, either new or converted from destroyers, seventy-six coastal minesweepers and seventy-nine inshore minesweepers, in addition to several seaward defence vessels and fast patrol boats. We have, moreover, at last begun to replace piston-engine aircraft with jets and are building submarines with a revolutionary type of propulsive machinery, as well as midget submarines. None the less, we have not laid down one surface vessel which will help to safeguard our world-wide focal trade areas against attack by cruisers, armed merchant raiders and long-range twin-jet bombers. Furthermore, now that the western forces in Europe are strong enough to withstand an unforeseen attack by the Russian army, it is surely time we gave some thought to the part the Royal Navy is to take in offensive operations necessary to achieve victory. In the following paragraphs the Royal Navy is discussed on the basis of the types and numbers of ships available, its commitments as the navy of a first-class naval power and as a member nation of N.A.T.O., and in the light of modern developments in material, weapons and equipment.

Numbers and Types of Ships of The Royal Navy

Battleships.—Our potential enemies have no worthwhile battleships built or building, but the Admiralty is wisely retaining five modern ships of this kind, four in "mothball reserve" (at a negligible cost), and one in commission for the training of personnel in handling and operating these vessels.



H.M.S. "Defender," a "Daring" class ship

Their main armament of 14in guns is unnecessarily powerful for dealing with any likely opponent and is also far less suitable than a carrier's aircraft for amphibious operations. But their powerful and concentrated anti-aircraft armament makes these ships very valuable as the hard core of a Task Force and they might well also provide the most suitable vehicle for launching long-range guided rockets, if the cost of conversion weae considered worth while.

Fast Carriers.—Under existing conditions naval aircraft have replaced the heavy gun as the most effective long-range missile launcher. They represent, in fact, the striking power of the fleet. With the introduction of high speed, heavy jet aircraft, it seemed that even to operate fighters and fighter bombers this would commit us to building carriers in future at least as large as the 36,800-ton "Eagle" to provide the length of deck required for flying-on. Moreover, the conventional hydraulic catapult—already enlarged and strengthened to the limit of practicable size—appeared unlikely to be able to launch the heavier, faster jets coming into service in the immediate future. Meanwhile the cost of construction has quadrupled since the war. The "Eagle" (see Plate 1, facing page 4) cost £16,000,000, compared with £4,000,000 for a 1939 carrier, and the figure for her sister ship—the "Ark Royal," to be commissioned this month—will be very much higher. It is, indeed, the heavy cost of these vessels which has led to the recent controversy on the value of carriers. Air enthusiasts and others with no experience of naval operations argue that they are uneconomical, very vulnerable and unnecessary in that the protection of sea communications could safely be left to long-range shore-based aircraft. Fortunately, British inventive genius has saved us from this dangerous alternative. In the past two or three years this country has produced the angled deck, enabling the fastest craft to land-on without interference with the handling of other aircraft on the flight deck; the steam catapult, which is of convenient size and can launch the heaviest aircraft; the side lift; and stronger arrester gear, in addition to other improved flight deck operational facilities, such as the landing mirror.

It is, in fact, now possible to operate all the types of aircraft required by the Royal Navy from fast medium-size carriers, which can be built at a reasonable cost. The recently completed "Centaur," for example, whose designed tonnage of 18,000 tons has probably now been increased to about 20,000 tons, cost no more than £10,500,000. Her sister ships, the "Albion" and "Bulwark," are also in, or about to be in, commission and the last of this class, the "Hermes," is still under construction. These four 30-knot vessels are in no way inferior to the "Eagle" in any operational role. They can carry and operate less than half the number of her aircraft and do not provide such a steady platform, but it is preferable for this country to have a greater number of carriers operating relatively few aircraft than to put all the eggs into one basket. There are many focal areas of trade to defend where air attack may be expected on a relatively minor scale. Equally, when carriers form part of a Task Force giving tactical support in amphibious operations, pending the construction of airfields ashore for the R.A.F., losses from submarine and air attack and from mines are likely to be heavy. With the "Eagle," "Ark Royal," the fast reconstructed wartime "Victorious,"

and the four "Hermes" class, the Royal Navy will have only seven modern carriers, a far from adequate number for the defence of the trade routes and for offensive operations in enemy waters. A carrier building programme should be begun without delay both to replace our old wartime fleet carriers, "Implacable," "Indefatigable," "Indomitable" and "Illustrious," and to provide the Royal Navy with adequate numbers of this kind of vessel.

Slow Carriers.—Including H.M.S. "Vengeance," now on temporary loan to Australia, the Royal Navy has six smaller, slower carriers of the "Glory" class, which were completed at the end, or soon after the end, of the war. They are of 13,000 tons displacement, with a speed of 24 to 25 knots, and were laid down at a time when economy in naval building was essential. As long as there are piston engine aircraft these six vessels will remain of some value for general reconnaissance and anti-submarine duties. There were also six similar but slightly larger carriers ("Hercules" class, 14,000 tons) building at the end of the war. Two of them ("Hercules" and "Leviathan") remain to this day in the half-completed state they were in in 1946. Two others, the "Magnificent" and the "Terrible" (renamed "Sydney") were transferred to the Royal Canadian Navy and Royal Australian Navy respectively. The remaining two, the "Powerful" (renamed "Bonaventure") and the "Majestic" (renamed "Melbourne") have also been purchased by the R.C.N. and the R.A.N. respectively and are now being strengthened and modernised to operate modern anti-submarine aircraft and earlier jet fighters.

It does not seem worth while modernising the "Glory" class carriers even to the standard of the "Bonaventure." Three of them, "Theseus," "Glory" and "Ocean," have indeed recently been earmarked for the Training Squadron, which gives initial training to General Service and National Service personnel. The two large fleet carriers, "Implacable" and "Indefatigable," previously so employed, have been placed in reserve, thus releasing men for the manning of the new "Hermes" class and "Ark Royal." The "Glory" class will in any event for some years prove useful as escort carriers to supplement converted merchant ships which, as in the last war, will again be employed for this service, either to operate piston engine anti-submarine aircraft or helicopters.

Cruisers.—The Korean campaign and policing operations since the war have amply demonstrated the value of cruisers for all kinds of duties and it is heartening to have the official announcement that a decision has at last been reached on the armament of the three "Tiger" class and that orders have now been given for their completion. In view of modern developments, work on their construction was suspended in 1946, which left us with no cruisers laid down or building since the completion of the "Superb" at the end of 1945. The "Tiger" class are each to have four 6in guns of a new kind, thus leaving ample accommodation for a strong anti-aircraft guided missile armament. The question of when and what kind of new cruisers to build presents much difficulty at the present time. By 1960 only five of our twenty-three cruisers—the "Nigeria" was recently sold to India—will be less than eighteen years old. None of them has a gun larger than 6in, while many of the Soviet cruisers have a main armament of 7·1in guns.

The Admiralty estimates that the Soviet Navy will have no less than thirty cruisers by 1957, an outcome of the substantial cruiser and destroyer programme begun after the war. Moreover, the "Sverdlov" and similar ships are reported to have a speed of 35 knots with a large cruising radius and thus to be well suited for attacking focal areas of trade in the oceans. In any event, our existing twenty-three cruisers are far from adequate to defend our world-wide trade routes and still less so if the Royal Navy is to take its proper share in offensive operations necessary for victory. On the other hand, with the introduction of surface-to-surface guided rockets, which may eventually replace guns as the main armament of ships, there may well be a requirement for fast vessels, with a closed-in armoured deck, of from 15,000 to 20,000 tons. The United States Navy is equipping two cruisers, a battleship and an aircraft carrier with launching platforms for firing guided missiles, and the Royal Navy is also fitting out a vessel as an experimental guided missile ship. Evidently there is still much doubt both as to the size and kind of ship required, and it is no doubt tempting, while N.A.T.O. remains in being and pending further knowledge of guided missiles, to rely on the sixty-eight cruisers of the United States Navy, all of which are between 10,000 and 17,000 tons and include twenty-six armed with 8in guns. But if we are to continue to be regarded as a first-class naval power and to safeguard our ocean trade routes in the Eastern Atlantic and Indian Ocean, for which the Royal Navy has a special responsibility, it is essential to lay down at least two more standard cruisers without delay. With the "Tiger" class, five new ships would then be available to replace the five cruisers which will next year reach their normal age limit of twenty years.

Destroyers.—Thirty-five of our forty-five destroyers earmarked for conversion to fast frigates for escort duties are now either completed or in hand for conversion. The destroyer, with her heavy gun and torpedo armament, was designed with the primary function of attacking squadrons of heavy ships with torpedoes by day and night and to prevent similar attacks on their own heavy ships by hostile destroyers. And as the Russian Navy will, it is estimated, have 150 modern destroyers by 1957, it may well be that a Task Force of carriers engaged in offensive operations in enemy waters will be subject to destroyer attack at night, in spite of the additional protection given by radar warning. But destroyers, with their limited range, are unlikely to be used as raiders on the ocean trade routes and as we shall still be left with sixty-five of these vessels, in addition to the "Daring" class, the building of more destroyers can with safety be deferred until the guided missile position becomes clearer.

Other Surface Vessels.—The gathering momentum of the rearmament programme begun in 1951 is now becoming evident with the launching or completion almost every month of some half a dozen vessels—frigates and lesser ships. All the twenty-five frigates provided for under the programme, are in course of construction and six have already been launched. They are of various types. The majority are being built for anti-submarine duties and these vessels again are divided into two types, one larger and having superior armament and equipment to the other. Some are intended for anti-aircraft protection of convoys; others again are being built for aircraft direction work, but all will be capable of employment in offensive operations against submarines. The chief difference between the various types lies in their size and in their main machinery. Anti-submarine frigates are fast vessels with a novel design of geared steam turbines of high power, while anti-aircraft frigates have Admiralty standard "Range I" diesel engines. All are of welded construction and have been designed with a view to rapid reproduction in emergency.

H.M.S. "Roebuck," formerly a destroyer, now converted to a first-rate anti-submarine frigate

The larger part of the new construction programme consists, however, of vessels specially designed for the purpose of keeping our coastal waters, ports and river estuaries clear of mines. The day is over when trawlers and drifters could be adapted for mine clearance work in view of magnetic and acoustic mines. Two types of minesweepers have been designed—the coastal minesweeper for operating in coastal waters and the inshore minesweeper for mine clearance in river mouths and harbour entrances. Of these ships, 155 (seventy-six coastal minesweepers and seventy-nine inshore minesweepers) are provided for under the programme and about 100 have already been completed. The coastal minesweepers —all 152ft in length—are being constructed in some twenty yards, including many not normally engaged in naval work and their hulls and framing are largely non-magnetic. One of these vessels—H.M.S. "High Burton," launched in June last from Thornycroft's yard—is to have the high-powered "Deltic" engine developed by D. Napier and Son, but the majority will be powered with standard diesel engines built by, or under licence from, Mirrlees, Bickerton and Day, Ltd. Inshore minesweepers are

some 50ft shorter than the coastal ships and are flush decked. All have diesel engines manufactured by, or under licence from, Davey, Paxman and Co. Ltd. Several more inshore minesweepers—to the value of 11,000,000 dollars—are being built under the United States Navy's offshore procurement programme for other N.A.T.O. countries.

Other small ships provided for under the programme are seaward defence vessels and fast patrol boats. The former, armed with a small gun and depth charges and powered by diesel engines similar to those designed for inshore minesweepers, are intended for the detection of submarines in the approaches to defended ports. Fast patrol boats are of three classes—the "Gay" class, "Dark" class and "Bold" class. All three are designed to be interchangeable as gun-boats or torpedo boats.

The Submarine and Anti-Submarine Position To-day

During the past year two underwater craft were launched, one in Britain and the other in the United States, which marked a revolutionary advance in the performance of this kind of ship. Both vessels have a power plant that requires no air, and propulsive machinery designed to operate at high speeds submerged at any depth desired. They are in fact the first two genuine submarines—vessels which are no longer submersibles with the ability to submerge when required, but which habitually navigate submerged. The need for a true submarine was foreseen by the Germans when developments in radar prevented their "U"-boats from remaining on the surface at night to charge their batteries. By the end of the war they were building underwater craft with a revolutionary closed-cycle engine using hydrogen peroxide as oxydant for fuel. They claimed that a vessel with two of these engines could proceed submerged at 25 knots for prolonged periods. Meanwhile they had developed as a temporary measure the snort breathing tube which enabled the "U"-boats to charge their batteries and make passages at speeds up to 10 knots while submerged at periscope depth. All existing modern submarines have since been equipped with this device. Moreover, through streamlining and the installation of increased battery power, the submerged speed of many existing underwater vessels has been increased to 17 knots, but only for a period of less than one hour (when their batteries must be recharged). The snort, however, can now be detected by radar under reasonably good weather conditions. Moreover, a burst of speed of 17 knots is quite inadequate for present day operational requirements submerged. Both the British and United States—and presumably also the Soviet—Navies, therefore, carried out exhaustive trials with the German closed cycle engine in the hope of improving its reliability and performance. Four years ago, however, an atomic power plant was becoming a practicable possibility for underwater vessels and the Americans decided to switch over to this new source of power and are now building two submarines—the "Nautilus" (which is now doing trials) and "Sea Wolf"—with a nuclear-powered plant. Another is to be laid down shortly. The British, on the other hand, appear to have had more success than the Americans in developing the German engine. For when the "Explorer" was launched at Barrow in March, the Admiralty announced that "she is designed to operate at high underwater speeds, and has propulsive machinery of novel design, employing hydrogen peroxide." Both this and a similar vessel now building, will soon undergo sea trials. A new and improved midget submarine, the "X51," was also completed last year and more are under construction.

It will be interesting to compare the performance and operational value of the "Nautilus" and "Explorer" during peacetime exercises over the next two years. The "Nautilus" is of well over 3000 tons displacement and is authoritatively stated to have a submerged speed of between 20 and 25 knots. Her very high underwater speed and endurance—the latter limited only by the endurance of her ship's company of ninety officers and men—give her operational advantages of the highest order. None the less, her very large size and cost—about £18,000,000—are obvious disadvantages. Officers experienced in submarine operations are not in favour of large submarines, which are much easier targets for Asdics and, with their large turning circle, are

H.M.S. "Explorer"—the first British genuine submarine capable of navigating submerged for prolonged periods without the use of a snort

unhandy and less easily manœuvrable in emergency. Nor is it by any means certain that prolonged high speed and endurance submerged are essential requirements for submarines of a naval Power which has the surface control of communications. Targets may be located in a submarine's radar a hundred miles away or more and, with the possibility of hostile aircraft in the vicinity, she can only intercept them safely by proceeding submerged at high speed for some hours. Similarly a chase by Asdic vessels may last equally long before the submarine succeeds—if she does succeed—in throwing them off the scent. But these operational requirements do not necessarily mean that high speed submerged has to be maintained for days on end or that a nuclear power plant for converting water into steam to drive the turbine engines is the best possible propulsive machinery for underwater craft. The "Explorer" is a much smaller submarine. She is, in fact, only 225ft in length, some 50ft less than the 1300-ton "Tally Ho," which made a "snorting" voyage last year from the vicinity of Bermuda to the English Channel. The need to carry hydrogen peroxide certainly sets a limit to the endurance of this submarine, but it should be adequate to meet the essential requirements set out above. Moreover, her submerged speed seems to be little less than that of the "Nautilus," as it has been officially announced that the "Explorer" will be able to maintain a speed of well over 20 knots. In any event it says much for the pioneering spirit of the United States Navy in trying out atomic plants in the only kind of ship practicable at the present time. For it would be impossible to over-emphasise the advantages for surface warships, particularly destroyers and lesser vessels, if they had the almost unlimited endurance at high speed given by a nuclear-powered plant.

The detection and destruction of these genuine submarines, operating at speeds of over 20 knots at depths of from 200ft to 500ft, present a very difficult problem unless and until they deliberately come within range of Asdic vessels by making a close-range attack. Measures for the detection and destruction of submarines have been immensely improved since the war and a submarine which continues her attack after being detected has a poor chance of escaping destruction. On the other hand, she may well decide to attack at long range with homing torpedoes, keeping outside the range of Asdic detecting devices. In which case, with her high submerged speed, it will be very difficult to detect and destroy her. The problem of detecting a true submarine is also made more difficult because of the ability of submarines to fire guided missiles. The Admiralty estimate that Russia will have 500 submarines by 1957, most of them of post-war construction, and it appears extremely probable that she will employ a substantial number strategically, in firing guided missiles and laying mines, which requires no great professional skill, initiative or judgment on the part of their commanding officers.

It would seem, indeed, essential to equip our 160-odd wartime frigates and other small craft with the latest kind of anti-submarine armament and to use them, in conjunction with aircraft and helicopters, to patrol areas 100 to 200 miles of our coasts, from which guided missiles are likely to be fired. Helicopters employ the sonobuoy, a device invented in World War II and since greatly improved, which they lower down to the surface of the water. The presence of a moving submarine is revealed by the detection of sound waves in the sonobuoy, which in turn transmits them, either by cable or by a small radio, to the helicopter hovering overhead. The sonobuoy can be hauled up again rapidly and the listening process repeated in an adjacent area as required.

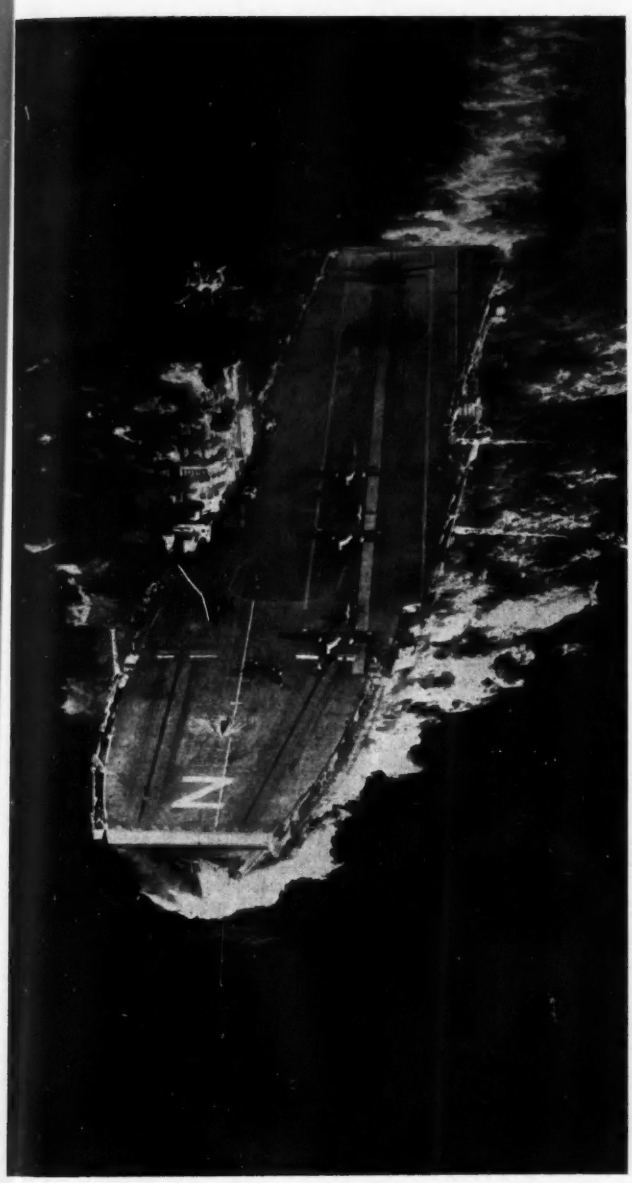
(*To be continued*)

Short Notice

Fluid Friction Coefficients. By J. R. Finniecome, M.I.C.E. Manchester: Emmott and Co., Ltd., 31, King Street West, 3. Price 10s.—This study—"the friction coefficient for circular pipes at turbulent flow," to give its full title—examines the investigations which have been made over the past hundred years into the friction drop in pipes. The published data of the various authorities on this subject are examined and the author has attempted to show the relationship of the various formulæ and test results from these different sources. The factors influencing the friction coefficient in circular straight pipes are reviewed, and a great deal of information on the pressure drop in smooth and rough pipes is correlated in charts and tables. The volume is divided into chapters dealing with the friction coefficients of smooth pipes and rough pipes, analyses of tests on commercial pipelines, and a bibliography and name index are provided.

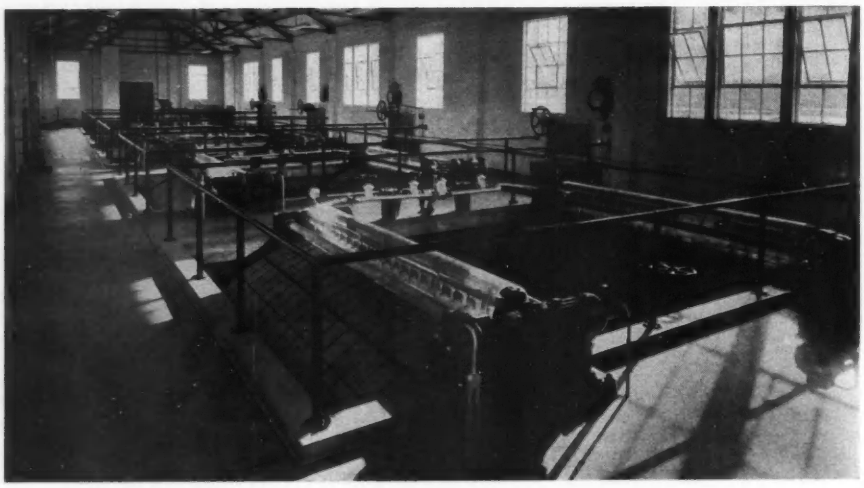
AIRCRAFT CARRIERS OF 1954

H.M.S. "Ark Royal" (right) is the largest aircraft carrier ever built for the Royal Navy. She has a standard displacement of 36,800 tons and a full-load displacement of 46,000 tons with a length of 720ft between perpendiculars (overall length 808ft 3in), a waterline beam of 112ft 9in and a maximum draught of 36ft. She will carry eighty to 100 aircraft and is armed with sixteen 4·5in dual-purpose guns in twin mountings, and forty 40mm Bofors anti-aircraft guns in six six-barrelled and two twin mountings. Her main propelling machinery consists of eight Admiralty three-drum boilers supplying superheated, high-pressure steam to a four-shaft arrangement of Parsons single-reduction geared turbines designed to develop an aggregate of 152,000 s.h.p. and to give a speed of 31·5 knots at deep load. Her keel was laid on May 3, 1943, and she is expected to be completed for operational service in 1955. The ship is fitted with the latest equipment for operating fast and heavy jet aircraft, including the angled deck, side aircraft lift and two steam catapults. Several successive recastings of her design retarded her building. She is the first British aircraft carrier to be provided with the steam catapult and the deck-edge elevator. The ship is of 90 per cent welded construction and her compartmentation and damage control arrangements are exceptionally complete. She will have a complement of over 2000 officers and men

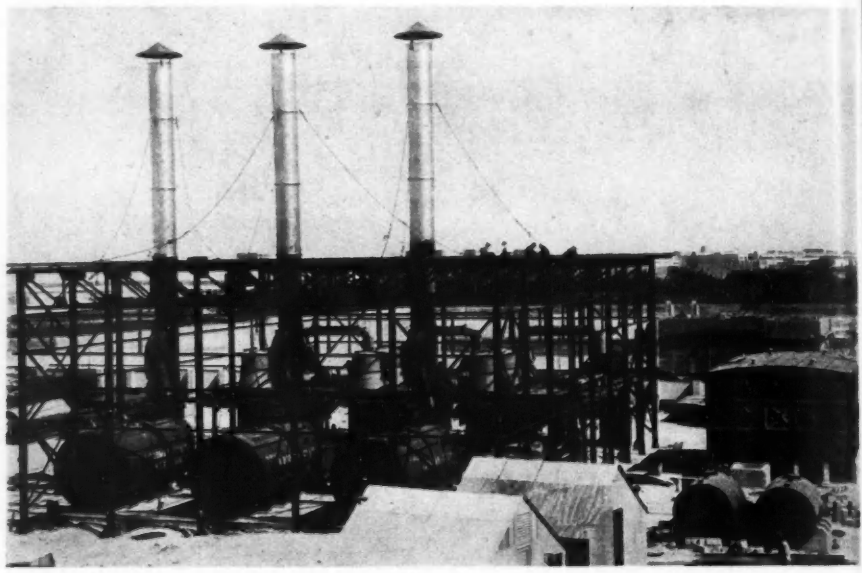


H.M.S. "Albion" (left) has a standard displacement of 20,330 tons, increased to 25,910 tons at full load, a length between perpendiculars of 650ft, and a beam at the water line of 90ft; she is 737ft long overall with an extreme breadth of 123ft, including the angled deck and the mirror deck landing aid, and has a draught of 26ft 3in. She is armed with twenty-six 40mm Bofors anti-aircraft guns in two six-barrelled, five twin-barrelled and four single-barrelled mountings controlled by close-range director systems. The main propelling machinery comprises a two-shaft arrangement of Parsons geared turbines taking high-pressure, superheated steam from four Admiralty three-drum boilers designed to develop 76,000 s.h.p., equal to a speed of 29·5 knots. The ship was intended to operate about forty-five aircraft, with approximately eighty officers and 950 ratings, exclusive of the aircraft squadron personnel, which will normally be between fifty and sixty officers and between 250 and 300 ratings. The design of this class of vessel was the subject of a long series of model experiments to determine the best shape of the hull for speed, endurance and seaworthiness. The hull strength and rigidity have also been the subject of special investigations. Welding was extensively used in the hull construction. The "Albion" is the first carrier to be fitted with the mirror landing sight, a device whereby the pilot of an aircraft comes in to land on a predetermined flight path by keeping a reflected light in the centre of the mirror which, in effect, carries out automatically the duties of a "batsman." The ship has a complement of aircraft consisting of Hawker "Sea Hawk" jet fighters, Westland "Wyvern" turbo-prop strike fighters, and Douglas "Skyraider" reconnaissance aircraft. Two Westland "S51 Dragonfly" helicopters are also carried. Electrical power is distributed by an armoured cable which encircles the ship internally just above the water line. Most domestic services are electrically driven. Should the ship be damaged an elaborate system of emergency cables can be rigged to enable essential services to be maintained

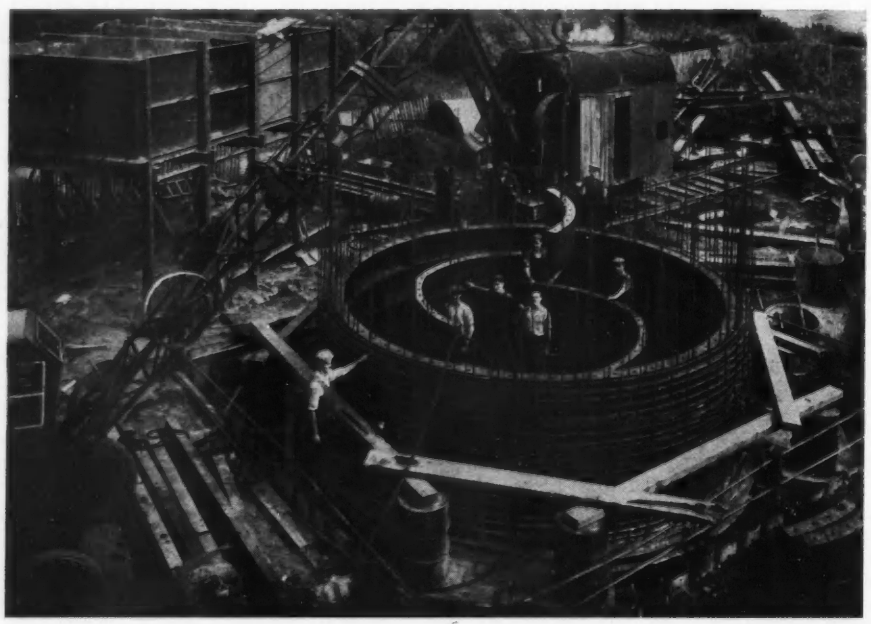
WATER SUPPLY IN 1954



The Metropolitan Water Board's remodelling scheme for Lee Bridge works has included the installation of ten micro-strainers, which are illustrated here. Each of the micro-strainers is 10ft in diameter and 10ft long between end micro plates, and they are arranged in pairs in five reinforced concrete chambers alongside the main aqueduct feeding the works. The whole installation can deal with a maximum flow of 55 m.g.d. The micro-strainers have been installed principally to deal with algal infestations; they have proved suitable for this task, and have the additional advantage for an existing works such as Lee Bridge that very little head is used in passing through them. This installation was designed under the supervision of the chief engineer of the Metropolitan Water Board, and the micro-strainers were supplied by Glenfield and Kennedy, Ltd.



The first stage of a water supply scheme at Doha for the Government of Qatar (Persian Gulf) is nearing completion. It will supply 120,000 g.p.d. (10 gallons per head per day), half this quantity from sea-water distillation, and the balance from saline underground water, obtained from groups of 6in diameter bore-holes about 12 miles from Doha. Water is to be piped to some buildings, but the bulk of the population will be served from tanks, placed at strategic points throughout the town. The sea-water distillation plant is shown here; Stage II of the scheme—a duplication of Stage I—is now being developed. Consultants, J. D. and D. M. Watson; contractors, Bennett, Sons and Shears, Ltd. (distillation plant), and Darwish Brothers, Doha (construction)



Glasgow Corporation Water Department's West Main tunnel under the River Clyde is 12ft in internal diameter with two 18ft diameter, 100ft deep shafts, both tunnel and shafts being lined with cast iron segments. One 36in diameter steel pipe will be laid in the tunnel for the time being, but a second can be laid if required. The length of the tunnel is 340 yards and nearly half was completed in 1954. The tunnel was driven from the south shaft, at first through boulder clay and then through boulder clay overlain by sand, silt and ballast, in compressed air at a pressure of about 35 lb per square inch. The approach to the tunnel on the north bank is by a reinforced concrete culvert. The south shaft is in a timber yard. Our illustration shows the north shaft reinforced concrete caisson with 10ft grabbing shaft inside the 18ft shaft. Consultants, Mott, Hay and Anderson; contractor, Kinnear, Moodie and Co., Ltd.

Labour in 1954

By GERTRUDE WILLIAMS

No. I

THE working population is now the most scarce of all our natural resources. The reduction in the birth-rate during the present century has cut down the new recruits to the industrial army to a much smaller trickle than it used to be, and, although the number of the community as a whole still continues to grow, the proportion of the total that are beyond the usual age for work becomes larger and larger. In the fifteen years since the beginning of the war those within the accepted working ages have increased by only a million, though the fact that there has been virtually no unemployment throughout the period may be said to have added a further million to the effective supply. From this slowly increasing reservoir must be supplied all the channels of production with their constantly changing demands for different types of worker.

Pattern of Occupational Distribution

Early last year there was published an analysis of the movement of the occupied population which shows the pattern of occupational distribution that has established itself since the end of the war. By 1947, demobilisation was practically complete, but many factors have combined to deflect people from the old fields of work and attract them into new. The rearmament programme, for example, has increased both the number in the Armed Forces and the number in the engineering industries engaged on defence work ; the restrictions on imports and the encouragement to export trades, have pushed workers out of some consumer industries, whilst, on the other hand, the removal of rationing and controls has led to an increase in the distributive trades. On balance, during the period between 1950–3, to which the figures in the analysis refer, agriculture, textiles and clothing, transport and public administration had lost considerable numbers, whilst the metal industries, engineering and vehicle building, the distributive trades and the Armed Forces were the principal gainers. Engineering, shipbuilding, vehicles and metal industries taken as a group had gained about 6 per cent (200,000 persons), though not all sections had gained equally. Those concerned with aircraft, ordnance, wireless apparatus, electrical engineering, machine tools and motor repairs gained most, whilst those making textile machinery, locomotives and rolling stock were fairly heavy losers.

Many of these industries have had great difficulty in finding an adequate supply of skilled workers and there has been a good deal more interest taken in the provision of carefully thought out apprenticeship schemes, with the aim of attracting and training young workers qualified to undertake the large amount of skilled work the expanding industries require. It is, therefore, of especial interest to see the directions taken by young people when entering the field of labour. Just over half a million boys and girls have been coming into employment each year, all but a comparatively small proportion at the age of fifteen. Of the boys, just over a third began an apprenticeship or learnership to a skilled craft, the largest proportion of these going into engineering, shipbuilding and electrical goods, and almost as many into building and contracting. Between them, these accounted for over 44 per cent of boys going into any kind of trainee employment, including articled clerks and professional services. Of the young school leavers as a whole, 47 per cent of the boys went into manufacturing industries, 14½ per cent into the distributive trades, and 12 per cent into building and contracting.

Amongst the girls, there is a much greater emphasis on the distributive trades, hotels and personal services, and a very much smaller proportion who enter an apprenticeship or any type of further training. This, of course, is easily explained by the expectation of marriage which makes a long training a very much less attractive capital investment for a girl than for a boy. Yet one of the interesting post-war developments is the marked increase in the proportion of married women in paid work. Indeed, married women account for 45 per cent of the total female working force and in some age groups—between thirty-five and forty-five—for fully two-thirds of all those employed. It must be borne in mind, of course, that many of these do not do full-time work. The figures are obtained from the national insurance records and a woman must have an employment card if she works for pay for as little as four hours per week. All the same, it represents a remarkable change in national habits. Before the war only one in nine married women worked at all for pay ; now the proportion is one in five, and the fact that the proportion is so heavy in the age groups indicated points to the conclusion that the majority of women give up paid work when they marry and have young families, but begin to re-enter the labour market as the children reach school age.

Older People

At the other end of the industrial army attention is centred on the work of older people. The scheme for retirement pensions was framed in such a way as to act as an inducement to those who have reached the pensionable age to stay on in employment as long as possible, and a great deal of propaganda has been directed towards convincing both employers and workers of the urgency of lengthening the span of the working period. But how far a promise of bigger pensions in the future might persuade men and women to postpone retirement was necessarily a matter for guesswork rather than knowledge. Recently, however, an attempt has been made by the Ministry of National Insurance to find out just what motives are at work in those who do actually stay beyond the minimum pensionable ages. The inquiry covered about 29,000 men and women who were either claiming the pension or who had just reached the pension age but had decided to stay on, during a particular four weeks of 1953. Of the men just reaching the minimum pensionable age 40 per cent were leaving work, a quarter because they were classed as chronically sick, a further quarter gave ill-health as their reason for retirement and an additional 3·6 per cent found their work too great a strain. Strain and illness became, as one would expect, more important factors with the older age groups. Of the men retiring between sixty-five and seventy, 38·1 per cent gave ill-health as the reason and 7·3 per cent gave strain.

A large number of men said they would have liked to stay on if they had been allowed but 28·4 per cent of those retiring at the minimum age said they were required to do so by their employers. It is probable that this insistence is related to the existence of employers' pension schemes but it seems that, to a certain extent, employers have not yet fully realised the importance of the age factor in the population situation. During the period between the two wars when statutory pension schemes first began to play a big part in social welfare arrangements, the existence of chronic mass unemployment led to a general acceptance of sixty-five as the " right " age for retirement and those who stayed on were felt to be outstaying their welcome by filling jobs that others could have done. There has thus become established a strong convention that workers " ought " to retire at the age when they become entitled to a pension and unless firms show more readiness to revise this attitude, no amount of persuasion directed to workers to continue at work as long as they are capable will be very effective.

Organisation and Supervision

One very valuable consequence of the slow increase in the size of the working population during a period of expanding demand is that much more attention is now being paid to good organisation and supervision. When each additional worker is precious it becomes a matter of urgency that the best use should be made of him. For some time there has been a growing recognition that it is wasteful not to equip him adequately with the best tools and capital equipment ; but the realisation that much of the effort put into this may be offset by slipshod or misdirected supervision has taken rather longer to gain ground. Yet the foreman represents the grade of management with which the worker comes most often into contact ; it is from him that the rank and file worker gets his instructions ; to him he looks to solve any immediate work problem and on him there depends that general amalgam of feelings that we call " good morale." The neglect of the important part played by the supervisor is, perhaps, part of the slow appreciation in general of the " imponderables " of human relations in productivity ; we are only just beginning to learn that efficient management is much more a human relations problem than anything else and a great deal of hard and constructive thinking needs to be done before we can be in a position to tackle the problem with any real hope of success.

Before the war it was rare to find any firm that devoted more than the most cursory attention to the selection and training of its supervisors, but in the post-war period many have begun, somewhat slowly and fumblingly, perhaps, to institute schemes for spotting and training their foremen and overlookers. Selection is, of course, more difficult and more important than training for the best supervisor is born not made. He has to have a natural talent which cannot be imparted though it can be developed and guided. But natural talent by itself is not enough. Even the best can be improved by training. This is true of any " personal relations " job. The doctor, the teacher and the lawyer need certain inherent gifts but they cannot do their jobs adequately by the light of nature without any special training ; and even those without outstanding talents can be prevented, at least, from making blunders if they are

given help in understanding their jobs.

Very few people have the gift of lucid exposition and a great deal of unnecessary friction arises in the workshops because of the lack of good, clear verbal communication. In addition to a thorough knowledge of the jobs done by the men under his control and the ability to give clear instructions, the foreman needs an alert and open-minded approach to changes in methods which may economise effort. Above all, he has to acquire some skill in the creation and maintenance of good working relationships within his own little group and in the contacts of his group with the rest of the firm.

Statistics based mostly on the Census of Population of 1951 show that, excluding working charge hands, there are about 300,000 foremen and overlookers in employment and, taking the normal wastage of retirement through age and sickness, this means an annual recruitment of about 10,000 new supervisors each year. There is, therefore, need for a constant programme of training if beginners in these grades are to get help in learning how to do their work—how, for example, to instruct new workers in what is required of them, how to pass on information that comes to them from higher ranks, and how to handle the innumerable small crises that crop up inevitably when a large number of workers have to co-ordinate their several activities.

Since 1944 T.W.I. (training within industry for supervisors) has been provided by the Ministry of Labour and National Service, and in the ten years of its operation about a quarter of a million people (including some members of senior management) have attended its short courses of instruction and discussion. Over the same period about 2000 employees of larger firms have attended five-day courses in order to qualify as T.W.I. trainers in their own firms.

This is a small beginning, but even a short course can do wonders to open men's eyes to problems of which before they were completely ignorant, and to stimulate their ideas. But the real value of these courses depends largely on the amount of "follow-up" that develops. Unfortunately too many managements look upon these short periods of training as a sort of "cooking process," after which the supervisor can be considered done to a turn. But any educative process must be continuous if it is to be of real help in opening mental horizons and encouraging new attitudes, and five days' exposure to stimulating ideas will not, by themselves, make a profound change in the capacity of a man to cope with complex situations. Yet this, evidently, is what a good many firms expect.

Training of Supervisors

The committee of enquiry into the training of supervisors set up by the Ministry of Labour with representatives of the Trades Union Congress and the voluntary bodies interested in this field, has reviewed the whole position in a report that has recently been published and has called attention to the unfortunate attitude of many managements. "The impression is given," it says, "that training may be regarded as an injection or series of injections and that often it may not have much continuing effect because of lack of interest on the management's part."

Quite a number of other efforts have been made in addition to the Government's scheme. Many of the larger firms have organised their own training schemes for their foremen, but this is hardly possible to any but the very big employer. For the others, however, help is available in evening courses provided by the Technical Colleges, the Industrial Welfare Society, the National Institute of Industrial Psychology, short conferences organised by the Adult Education Centres and so on. Several voluntary societies have grown up to give opportunities for those specially interested in this work to meet and exchange ideas; for example, the British Association for Industrial and Commercial Education, the Association of Supervisors' Discussion Groups, and the Institute of Industrial Supervisors. Yet the Committee was forced to the conclusion that the development of supervisory training is still in its infancy, that only a tiny proportion of supervisors receive any training at all other than what may be provided within the firm itself by some of the larger employers and that the facilities available for training are not fully utilised.

The Committee did not fall into the mistake of assuming that the major part of training could possibly be done by outside agencies, however excellent the courses and discussions offered; in fact, they expressly stated the opposite view. Inevitably, the supervisor must acquire most of his skill on the job and the most valuable lessons he can learn are those taken from the example of those above him in the management chain. The training of supervisors cannot be accomplished successfully in isolation from the rest of the firm; it must be part of an integrated and comprehensive system throughout the company. But, in the words of the report:

"The necessity for the interest and support of all levels of management needs to be particularly stressed, in the case of supervisory training, because the whole concept of such training is a comparatively new one to many branches of industry and the need for it is not always recognised by the lower levels of management, including very often the supervisor himself. Active co-operation from the supervisor is, of course, essential, but this is much more likely to be given if he sees that members of management at all levels (and particularly those with whom he comes into direct contact) attach real importance to his training, understand its principles, and intend to give him the full opportunity of developing his abilities and applying his newly acquired knowledge."

As yet there are many, perhaps even a majority of managements, which are not fully convinced of the value of specific training and are content to go on as they have done in the past, assuming that foremen can pick up their skills as they go on with their work. As long as this belief continues, productivity will remain lower than it could be with the same effort and capital equipment, and there will continue to exist constant interruptions to the even flow of work, due to the uncontrolled friction of human personalities.

Wage Claims

The past year has seen the regular cycle of wage claims that has now become part of the accepted industrial pattern. Until recently the majority of claims were based on the continuously falling value of money and the need for readjustments in money rates, simply to keep real wages constant. In the last year or so, however, this claim has lost much of its force, for the Retail Index has not moved very greatly. At the same time it has played its part in wage claims, for the prices which are most important to the worker in the lower income ranges—food and rent and rates—have risen more proportionately than the cost of living in general.

Wage rates as a whole have just failed to keep pace with the rise in the Index; but wage rates are less important to the standard of living than weekly earnings and these have far outstripped prices. In April, the last period for which the changes are analysed, the average earnings of adult men had risen by 60 per cent since 1947, whereas prices had gone up by only 44 per cent.

Workers complain that this comparison is in no sense valid as an argument against increases for two reasons. In the first place, the bigger pay packet is the result of harder work, which should show in more earnings. In this they have much on their side, for the figures just quoted refer to a working week (overtime included) of 48·3 hours, whereas the average hours worked in 1947 were 46·3. In the second place, they insist that there is nothing sacred about the wages of 1947—they are taken as the basis of comparison simply because the present Retail Prices Index dates from that year. Since then the great economic recovery of the country and the notable increase in productivity have provided a larger cake to divide and it is only fair that workers should get a larger slice.

Both these arguments played an important part in the disputes that took place early in the year in the engineering and shipbuilding industries following the demand for an all-round increase of 15 per cent in time rates. As there is a considerable amount of piece work in both these industries the net effect would have been a rise in earnings of about 12 per cent and this the employers were unwilling to face. A threat to ban overtime if the demands were not conceded led in both cases to the setting up by the Minister of Labour of a Court of Inquiry.

The reports of these two Courts surveyed the recent history of the industries and reviewed the economic background. In shipbuilding average earnings based on a forty-four-hour week had not risen as much as the cost of living, whereas productivity measured in tonnage per worker was much higher. Certainly most of this increase was due to improvements in plant and methods, but it was natural for workers, without whose co-operation it could not have been achieved, to claim a share in it. On the other hand, shipbuilding is a highly competitive industry and although the labour cost is nothing like so high as it is in some other industries, higher wages must be reflected to some degree in prices. Even a modest rise in prices might induce buyers to place their orders in foreign countries or to move their vessels to foreign ship-repairing yards.

The same problem was uppermost in the Court's mind with regard to the engineering industry. It was calculated that, taking certain representative branches of the industry, the effect of the wage claim would be to put up prices by about 8 per cent. For an industry whose products had accounted for 41 per cent of the value of total exports in 1952 this was not something to be lightly undertaken. Nevertheless, in both cases the Court felt a case had been made out for some advance and recommended an increase of 5 per cent instead of the 15 per cent asked for. This advance set the pattern for the majority of wage increases in other industries throughout the year.

(To be continued)

Pictorial Review of Oil Activities.—The British Petroleum Company, Ltd., has published a brochure which is a pictorial review of the world-wide activities of the company. These pictures represent activities in Canada, Zanzibar, Trinidad, New Guinea, and in the several refineries situated in Great Britain, Aden, Australia and Europe.

Coal in 1954

By SIR RICHARD A. S. REDMAYNE, K.C.B.

No. I

I. Great Britain: The Year 1953

THE National Coal Board's annual report for the year 1953 was not issued until May 20th last. Commenting thereon *The Times*, in a leading article under the heading "Coal in the Doldrums," said that "Last year's achievements gave little reason for satisfaction, except possibly the increase of capital investment."

The final results for the year 1953 were not available until well into the following year. But according to provisional figures issued by the Ministry of Fuel and Power on January 5, 1954, the output amounted to 223,518,600 tons, which was 1,267,200 tons less than in corresponding fifty-two weeks of 1952, and marked the first drop in production in any year since the coal mining industry was nationalised. According to this estimate, 211,815,100 tons were derived from the mines and 11,703,500 tons from opencast working, the latter being 402,500 tons less than in 1952 and the mined coal 864,700 tons less. According, however, to the statistics issued by the National Coal Board—in May, 1954—the total of mined coal in 1952 amounted to 210,469,279 tons, which was equal to 99·0 per cent of total saleable tonnage (including licensed mines). It was estimated, by the Ministry of Fuel and Power that about 1,000,000 tons were lost on account of the Coronation holiday and about 4,500,000 tons as the result of the extra week's holiday, which the miners took for the first time in 1952.

For a considerable time during the year output had been falling regularly below the preceding year, and manpower, which had begun to fall at the beginning of 1953, also fell rapidly from midsummer onwards, and absenteeism, during long periods, showed an increase. In the last two months of the year, however, there was a marked improvement.

Sir Hubert Houldsworth, the chairman of the N.C.B., commenting on January 6, 1954, on the results for 1953, stated, amongst other items, that attendance at work was poorer over the whole year than in most years since the war, but after the second week's holiday had been taken, the general level improved considerably. Absenteeism during the second half of the year was, overall, 11·2 per cent, compared with 11·6 per cent. The proportion of the coal industry's labour force employed at the face, Sir Hubert said, was in 1953, 41·8 per cent. This is a useful figure to have in mind when considering the matter of output.

The weekly average number of face workers was 300,000, or 6000 above the 1952 average, and the total number on the colliery books averaged 717,000 a week, compared with 716,000 in 1952; by the end of 1953, however, the total manpower at the mines had fallen to about 710,000. There had been no large stoppages of work at the mines during the year, the quantity of coal lost through disputes being 940,000 tons, was substantially below the 1952 figure.

Inland coal consumption had amounted to 207,500,000 tons for the year, and exported coal, together with bunkers, had reached 16,500,000, or 1,509,000 in excess of the 1952 figure. Distributed stocks at the end of December, 1953, were 18,500,000, nearly 2,000,000 more than at the end of 1952. From the statistics issued last May by the N.C.B., we learn that cost per ton of saleable coal over 1953 was 59s. 2·4d., as against 56s. 2d. per ton in the previous year, proceeds per ton being 61s. 1·5d., giving a profit per ton of 1s. 11·1d. The total profit (before charging interest) was £20,287,643. But the net surplus amounted to only £353,647 after discounting interests payable, taxation and loss on imported coal. This compared with a deficit of £8,200,000 the previous year. The deficit accumulated since 1947 was reduced to £13,600,000.

The average wages of the various classes of workers earned during the year (in comparison with those earned in the year 1954) are stated under the heading "earnings" in succeeding pages. Capital expenditure amounted to £64,300,000, compared with £48,600,000 in 1952.

The Year 1954

It will be surmised from the preceding what was the state of the great coal mining industry at the commencement of the past year. In recording the economic and other changes and developments which have characterised the present year, we have to rely largely for our fundamental facts upon the admirable quarterly statistics issued by the National Coal Board. But unfortunately, as in past years also, only those appertaining to the first three quarters are available at the time of writing.

Financial

We have seen that although during 1953 the colliery profits amounted to £20,287,643, to which must be added the profit earned on opencast working amounting to £2,117,704, the deductions due in respect of other items, e.g. interests payable, loss on imported coal, provision for taxation, &c., left a surplus of only £353,647. So, in respect of the first three quarters of the year 1954, heavy deductions have to be made from colliery profits. Thus, in the first three quarters of the past year, we note that though in the first quarter the collieries made a profit of £5,523,133 and an estimated profit as well in regard to ancillaries amounting to £740,000, the Board made a loss of £12,000 in opencast working of coal, and after deductions in respect of interest, provision for taxation, &c., the estimated net surplus for the quarter amounted to only £541,133. In the second quarter the colliery profit was £4,650,095, which, together with a profit of (estimated) £900,000 from opencast workings and of £200,000 from ancillaries (estimated), amounted to £5,750,095, yet, when all deductions had been made, including an item of £420,000 on imported coal, there remained a deficit for the quarter estimated at £264,905. In the third quarter the colliery profit was £47,586, which, with a profit of (estimated) £750,000 from opencast workings and £240,000 from ancillaries, left a combined profit of £1,037,586, which, after deducting £405,000, for an adjustment between a loss of over £2,000,000 on imported coal set against reduced provision for taxation, the estimated operational profit came to £632,586. The further deduction of interest payable to the Minister of Fuel and Power of £4,650,000 left a deficit of £4,017,414.

So far, from the money earning point of view, the record hardly seems to bear comparison with private enterprise, though from some other aspects it may.

Output

The quarterly statistics issued by the N.C.B. relate only to the coal produced at the collieries, that obtained from opencast workings not being included. It will be remembered, too, that prior to the last world war, opencast working of coal was not practised in the United Kingdom.

The outputs obtained at the collieries of commercially disposal coal, during the last quarter of 1953 and the first three quarters of 1954 are given in Table I.

Table I.—*Quarterly Coal Output*

Quarter	Total of saleable coal	Consumed at mines	Miners' coal	Available for sale
4th quarter, 1953	56,422,234	2,391,874	1,366,487	52,663,873
1st quarter, 1954	54,919,177	2,502,351	1,459,654	50,957,172
2nd quarter, 1954	53,074,351	2,330,339	1,239,166	49,504,846
3rd quarter, 1954	47,780,555	2,129,609	1,104,189	44,546,757

A great deal of nonsense is talked about the coal output of the United Kingdom; for instance, the *Daily Herald* newspaper stated (June 23, 1954) that the "nationalised pits give us 26,000,000 tons a year more than private industry did." But one must not pick upon one particular year for the sake of comparison. For were one to take the year 1913, when, under private enterprise, the coal output of Great Britain attained the record figure of 287 million tons—or about 60,000,000 above the output of the year 1953—one must be careful before one makes deductions thereon to take into consideration and weigh such factors as, for instance, number of persons employed, the extent of mechanisation, hours of employment, the extent of absenteeism and, if the comparison is over a long period in point of years, whether there has taken place any change in the physical and geological character of the seams of coal (such as the respective thinness of the seams being worked in each case, the depth at which the seams worked lie, &c.).

Taking the broad and comprehensive view of the situation and weighing all the factors, nationalisation of the mines does seem to have failed to implement the prediction of its advocates that it would result in the production of "cheap and abundant supplies of coal." The true test of efficiency is determinable by the output per manshift, and by the regularity of the attendance at work, and great strides have of recent years been made in the invention, design and application of labour-saving devices (which are included under the term "mechanisation" of the mines) which should have resulted in a greatly increased output per manshift.

A bright feature was announced by Sir Hubert Houldsworth, speaking in London on January 6, 1954, when he said that further progress had been made with the national reconstruction plan, and that ten new pit sinkings were in progress, and that during the year 1953, twenty-three large schemes were approved for the reconstruction of existing collieries, bringing the total authorised expenditure on larger projects to about £150 million. The output of the collieries concerned will, he said, be raised from about 50,000,000 tons a year to 78,000,000 tons.

During the earlier part of the year concern was evinced by the National Coal Board about the disappointing rate of coal output so far for this year. It will be remembered that in January, when the last wage settlement had been reached, the two sides agreed to take all practicable measures to obtain a minimum of 2½ per cent increase in production the year (1954), equal to about 5,000,000 tons, but, judging from the results over the first eighteen weeks of the year, the output was little above that of the year before, while opencast production had dropped by 175,000 tons, and 160,000 tons had been lost by disputes. The drop in production was heaviest in Scotland.

The N.C.B. and the National Union of Mineworkers arranged for a joint meeting on May 20th to consider what steps should be taken to meet the situation. At this meeting the union's representatives accepted the seriousness of the position and decided to call a special executive on May 27th to consider what could be done about it, after which a further meeting with the N.C.B. must take place. The miner's union warned the workers of the gravity of the situation, but little positive action seems to have resulted therefrom.

As *The Times* correctly said in its leading article of May 22nd last—already mentioned—referring to the annual report on the industry for 1953 issued by the N.C.B.: "As the report shows, the industry has ample men, they are better deployed, there is better training, there is more capacity—more coal faces ready for working—there is much better equipment and more mechanisation. But no more coal."

The situation in respect of the prospective shortage of coal was so serious by the middle of the year that Mr. Geoffrey Lloyd, the Minister of Fuel and Power, stated in the House of Commons that he had authorised more coal imports. For, compared with 1953, we had used 3,000,000 tons more, and, though we had produced 1,000,000 tons more, we had stocked 1,500,000 tons less, and had exported (together with bunkered in ships) only the same as last year. Up to that date the Government had already imported 366,000 tons of coal, mostly from France, the rest from Germany, Belgium and Poland. The Minister was attacked by members of the back bench Conservative fuel and power committee in the House on June 21st, who had demanded, earlier in the year, a full-scale inquiry into the operations of the National Coal Board, a demand flatly rejected by the Minister.

By September the position had not improved. On the 15th of that month, at a meeting of 200 industrialists in Sheffield, Sir Hubert Houldsworth said: "It is a most serious situation. But we are doing all we can to avoid a breakdown of industry by importing coal and by striving to raise home production. Much will depend on the weather." Reserves were then down 440,000 tons.

Costs of Production: Proceeds and Profit Per Ton of Saleable Coal

Table II shows the costs per ton and profit earned per ton for the last quarter of 1953 and the first three quarters of 1954. It will be seen that, in view of almost constantly rising costs, a profit is only maintained by an increase in the selling price of coal.

It will have been observed from a study of previous articles that cost of production has risen considerably during the last few years and that for the year 1953 at 59s. 2·4d. was the highest recorded in respect of any full year since detail statistics have been available. In the second quarter of the past year it will be observed from Table II that even this high figure has been exceeded, due largely to the increased wage rates granted in January last to the miners. But the tendency has also been for a gradual rise in the cost of materials employed in the mines. One does not begrudge to the miners a high rate of wages; the nature of their employment fully warrants it, but surely it should carry with it a regular attendance at work. Especially now that the miners have been granted the annual holiday in addition to their specified day-holidays. The fact remains, however, that the curve of voluntary absenteeism tends to rise with a rising rate of remuneration. The only practical means for the reduction in the cost of production is by the increase in the output per manshift per day and the reduction in voluntary absenteeism. The great development in the design and application of coal-cutting and conveying machinery at the face witnessed in the last few years should have been more largely reflected in the output per man per shift than it has so far been.

Table II—*Cost per Ton of Production on Saleable Coal, Proceeds and Profit*

Quarter	Wages*	Roof supports, general stores and repairs	Coal and power consumed	Other costs (including depreciation)	Total costs	Proceeds	Profit or loss
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
4th quarter, 1953	35 9·4	10 4·9	3 1·3	9 1·4	59 4·9	62 4·2	2 11·3
1st quarter, 1954	36 2·5	9 7·4	2 11·7	8 5·7	57 3·4	59 3·5	2 0·1
2nd quarter, 1954	38 3·0	10 6·2	3 2·6	9 6·1	61 5·9	63 2·9	1 9·0
3rd quarter, 1954	38 5·4	10 9·4	3 5·3	10 5·1	63 5·2	63 5·4	0 0·3

* Inclusive of holiday pay and allowances in kind.

Prices and Quality of Coal

It was announced by the Coal Board on April 14th last that on May 3rd there would be a rise in the price of coal, that the most popular grade of house coal—Grade 4—would be increased by 5s. a ton. The average increase worked out at about 4s. 4d. per ton for household coal, or 2s. 10d. for all inland coal, as certain grades were not increased in price, and the two lower grades 6 and 7 would be cheaper. Grade 3 went up 9s., while Grade 6 dropped by 5s. and Grade 7 by 6s., so that on May 3rd London prices were: Grade 3, 135s. 2d.; Grade 4, 125s. 2d.; Grade 5, 116s. 2d.

The price of industrial coal was also increased. The railways having to pay 4s. 4d. pet ton extra, gas 3s., electricity 1s. 5d., iron and steel 2s. 11d., and general industry 2s. a ton more.

So it is estimated that these increases would put up the cost of the national coal bill by £27,000,000. The railways, which are users of high-grade coal, it was estimated, would be very hard hit, it being estimated that their expenditure on fuel would be increased by £3,000,000 a year. As house coal would go up by an average of 4s. 4d. a ton, the cost of this item in the family budget will be increased by £7,000,000 it was estimated. The increase to the gas industry would be about £4,000,000, to the electrical industry by £2,700,000, and the iron and steel industry £1,000,000.

The Coal Merchants' Federation of Great Britain stated on April 14th that, owing to the increased mechanised production of coal, less of the large-sized coal required by householders is now available and relatively more of the smaller sizes used by the manufacturing industry and power stations, so that it is unfair that householders should be subject to discrimination. As they rightly said, "The average pit price of industrial coal is substantially below the average for all coal, although it costs just as much, and sometimes more, to produce. Householders are thus already subsidising industrial users."

At current prices the Board was faced with a deficit of £17,000,000 in 1954; hence the increase in coal prices. The increases are to avoid this, but not to liquidate past deficits. "How soon then will the N.C.B. begin to fulfil its duty of balancing its accounts over a period of good years and bad?" asked *The Times* in a leading article entitled "Coal Prices Policy," in its issue of April 5th. "So far all the years have been good years, with lively unsatisfied demand, with export markets healthy and asking for more—and, moreover, paying more than the domestic consumer. Is it the intention to charge fully remunerative prices at last just when world demands for coal are easing, so that home prices rise most when oversea prices are falling? The new price increases are not designed to cover the higher wages recently awarded because the cost of these would be defrayed if output were increased by 2½ per cent this year, which the Coal Board and the miners' unions consider a reasonable aim. The expected increase in costs which the higher prices will cover does, however, include local additions to piece-workers' wages, which carry earnings up faster than is provided by the national wage awards."

Contrary to the view taken by the Coal Merchants' Federation, *The Times*, in the article quoted above, said: "The Board is moving in the right direction. Scarce coals are also almost invariably dear to mine, being either less accessible or (as with large coal) not mined successfully by modern mechanical methods. Thus in practice the N.C.B. is sensibly charging higher prices for coals which cost more to mine; though it might still be reluctant to admit this as a guiding principle in its price policy."

Table III—*Average Earnings per Manshift Worked and per Wage Earner per Week at Collieries plus Value of Allowances in Kind, Over the Last Quarter in* 1953 *and the First Three Quarters of* 1954

Quarter	Per manshift worked				Per wage earner per week			
	At the face	All underground	Surface	All workers	At the face	All underground	Surface	All workers
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
4th quarter, 1953	57 9·5	49 10·4	33 3·3	46 1·3	287 11	261 10	191 9	247 0
1st quarter, 1954	56 1·8	48 7·8	32 7·8	44 10·7	279 10	254 11	189 0	240 7
2nd quarter, 1954	59 0·8	51 0·2	35 4·1	47 5·9	279 7	250 7	198 5	244 7
3rd quarter, 1954	59 6·3	51 2·0	35 2·4	47 6·6	253 8	234 0	184 0	223 10

Note.—These wages are inclusive of the value of allowances in kind.

Personally, the present writer after many years' practical experience in the getting of coal, cannot agree that the undercutting of a coal seam by mechanical means should or does produce less large coal than was obtained by undercutting by the hand-wielded pick in universal use at one time. By the use of hammer drills and the coal plough—yes.

Sir Hubert Houldsworth, at the opening of the National Coal Board summer school on September 12th, said that dirtier seams were now being worked of necessity, compared with the immediate pre-war years, and consequently there was a constantly widening gap between what was raised and weighed and what was saleable. But is this really the case ? Thinner seams are being worked at the collieries, but the writer doubts greatly whether dirtier seams are. Certainly the coal produced by opencast working is obviously much dirtier than that mined at the collieries. That is quite obvious.

Miners' Wages

Table III shows for the last quarter of 1953 and for the first three quarters of 1954 the total average earnings of the male workers of all ages at the collieries employed underground and at the surface, but does not give the average earnings of "detailed classes" of worker ; thus, for instance, those employed at the face include those actually engaged in "getting" the coal, also those engaged in ripping and packing. There are many separate classes employed, particularly underground, performing widely different kinds of work, e.g. hewers, store men, haulage hands, shifters, onsetters, &c., and at the surface a variety also, e.g. banksmen, screeners, fetters, &c.

The miners' union had towards the end of the year 1953 been discussing with the Coal Board its demand for rises in the wages of the lower-paid or day wage men known as "datallers," numbering about 400,000 at the collieries ; their claim amounted to 2s. 3d. a shift for those employed underground, and 2s. 7d. for those at the surface, which, if met in full, would have cost about £14,000,000 a year, and have added at least 1s. 6d. to the price of coal. Finally, on February 11, 1954, the miners accepted the Coal Board's offer of increases of 8s. 6d. a week for underground workers and 7s. 6d. for surface men. These advances would, it was estimated, add nearly £10,000,000 a year to their wages bill. It was expected, however, that the Coal Board would recover all of this from a big increase in output, the miners' union agreeing that the improvement in miners' standard must be paid by greater efficiency, and they accepted a 2½ per cent production increase as the minimum target for 1954, which would provide an extra 5,000,000 tons of coal, and the union leaders promised to continue and intensify the joint efficiency campaign towards achieving this result. But, alas, up to date the desired end does not appear to be likely to have been compassed, for, as the Minister of Fuel and Power stated in the House of Commons on June 21st last, so far there had been no increase except for 1,000,000 tons because there was no Coronation holiday this year. He added, "We desperately need more output."

(To be continued)

Hydraulic Couplings.—We have received from the Fluidrive Engineering Company, Ltd., the January issue of *Fluidrive News*, which commemorates the twenty-five years' existence of the company. It reviews briefly both the progress made and the many uses to which the Vulcan-Sinclair fluid couplings have been applied during the years 1930–1955.

Civil Engineering in 1954

No. I

THE civil engineering industry is not one whose achievements over a year can be precisely given in statistical form, as can be done, for example, in shipbuilding or in coal mining, where tonnages can be stated to give an exact measure of the year's work. Official statistics, which are compiled by the Ministry of Works, relate to building and civil engineering taken together, and a clean division between these two cannot easily be made. Nevertheless, the overall figures are not without interest. The total output of building and civil engineering work in 1953 was £1,741 million, and in the first half of 1954 the total output continued at almost exactly the same rate. Previously, there had been progressively increasing totals from £1198 million in 1949. New work stood at £575 million in 1949, £1063 million in 1953, and £541 million in the first half of 1954. Thus, the extent of the easing of restrictions on new works may be seen. Of the divisions in the official statistics, those for opencast coal production and water and sewerage relate to civil engineering alone. Expenditure on opencast coal was at the annual rate of £17,400,000 in 1954, according to the incomplete figures available when going to press, and water and sewerage (new works) at £29,400,000 Apart from a slightly higher figure in 1953, water and sewerage expenditure had been steadily rising from only £9,800,000 in 1948.

An indication of the relative expenditures in different sections of the civil engineering industry can, however, be obtained from the *Tabular Summary of Civil Engineering Contracts* for 1954, which was published as a supplement to the December 24th issue of The Engineer. The *Tabular Summary* does not show work completed in one year, but lists contracts in progress during the year, some of which take many years to complete. Also, it only includes contracts valued at £50,000 or more, the smaller contracts being omitted. The total value of the water supply and drainage and sewage contracts listed (excluding overseas works) is in the region of £140 million ; this compares with the annual rate of about £30,000,000 quoted above and implies that the average contract is taking, very roughly, five years or so to complete. The total value of all the contracts in the *Tabular Summary* approaches £750 million, implying an annual rate of the order of £150 million on civil engineering ; nearly a third of the last two figures relates to work abroad, and two-thirds to work in this country. The *Tabular Summary*, however, does not include Government contracts about which details cannot be published.

Of the various classes of work listed in the *Tabular Summary*, the most important concerns power stations ; civil engineering contracts totalling about £120 million were in progress in this country in 1954 for power station construction, but it may be that the average time taken to complete a contract is longer with this class of work. Nevertheless, the important influence of the B.E.A.'s equipment programme on civil engineering is evident. The water supply section and the structural and industrial section are almost equal in value, and are each about two-thirds the value of the power station contracts. But the structural and industrial section verges on the borderlines of mechanical and chemical engineering on the one hand and building on the other. Hydro-electric and drainage and sewage contracts at home each stand in the *Tabular Summary* at between £50,000,000 and £60,000,000, and railways and harbours and docks each around £40,000,000. The other sections are much smaller. The pattern of works abroad, for which British consulting engineers are responsible (i.e. not including overseas contracts held by British contractors but with foreign consultants or supervising authorities) is rather different. Contracts to the value of over £200 million were in progress in 1954, nearly a quarter of this total being dock and harbour construction. Thus, a larger total of dock and harbour work was

Quay No. 1 under construction at Tilbury Dock. Monoliths under process of sinking are shown in the foreground

Pulo Bukom oil berth. The heavy reinforced concrete berthing beam is clearly shown, with timber fendering on its seaward face

in progress overseas than in this country. Generally, the figures quoted above show only small changes from the totals of the *Tabular Summary* for 1953.

These few figures illustrate that the cramped economic position of the post-war years, which was felt particularly by the civil engineering industry, was eased considerably by 1954. Only in the construction of new roads was the industry forced to be idle.

Coast Protection and Land Drainage

The bad weather conditions experienced during 1954 once again drew the attention of civil engineers to problems of flood relief and coast protection. Coastal storms caused breaches and quite severe damage in a number of sea defences during the year, and there were floods due to high rainfall in several river catchments. The Waverley Committee published its report on the 1953 storm surge last June. The report, and the East Coast sea defence works, have been fully described in these columns, so no further description need be added here; but it may be noted that some disappointment was expressed that the Waverley report was not more positive in its recommendations. One of its proposals—for a surge-reducing barrage in the Thames estuary, formed the subject of a paper at the Institution of Civil Engineers, which was discussed in The Engineer of October 29th last.

Last year, at this time, we recorded the completion of the first stage of a comprehensive flood alleviation scheme on the River Welland. Another fen river—the Great Ouse—requires even more elaborate works for flood alleviation, and a start was made during the year on the Great Ouse flood protection scheme, work being commenced on a relief channel 10¼ miles long which will require extensive earthworks, regulators and bridges. The contractor is Sir Robert McAlpine and Sons, Ltd., and the consulting engineers are Sir Murdoch MacDonald and Partners; the work so far let is valued at nearly £3,000,000 and further work of similar magnitude involving a cut-off channel is to be started in 1957.

Kingston-upon-Hull was in the news on several occasions last year, owing to flooding, and so a brief account of some work in progress in that area has a topical interest for this review, and will serve as an example of what is being done by civil engineers to obviate flood problems such as those encountered so frequently in 1954. A completely reconstructed main drainage scheme for the whole of the city and much of the adjacent urban district of Haltemprice was first conceived in the middle 1930s, but only in 1945 was any practical progress made, and in that year orders were placed for the first section of the work which was at that time confined to the most easterly parts of the city. The West Hull and Haltemprice joint main drainage scheme was, however, commenced in 1948 and since that time there have been very extensive works in hand in the extreme west of the city and in the adjacent urban area. A 10ft 9in diameter outfall sewer was constructed to the Humber estuary from a new pumping station site; the new pumping station was rather more than half finished at the end of last year, and some miles of trunk sewer were in course of construction, in open cut and in tunnel.

The current main drainage problems of Kingston-upon-Hull are, it is believed, without parallel in this country. Practically the whole of the city is below the level of high-water spring tides; the catchment area is divided by the River Hull, which flows from north to south through the city and which itself creates a serious flooding problem from time to time, and the technical design is further complicated by the fact that the level of the land, which forms a continuation of the Lincoln Marsh across the Humber, falls from the Humber Bank for a distance of about 4 miles. It follows, therefore, that the sewers have, of necessity, to be laid against the general fall of the land in most indifferent subsoil and at considerable depth at the main pumping station, which is close to the Humber. The fact that no relief can be afforded in times of flood by storage methods means in effect that the pumping plant must be capable of handling the maximum run-off at all times and, in fact, the ultimate design to capacity of the pumping station is 63,000 cubic feet per minute against a total head of 45ft to 50ft. This work is being carried out under the direction of the city engineer of Kingston-upon-Hull, Mr. William Morris.

Some Maritime Works

Some examples of dock and harbour construction in progress during 1954 are illustrated on Plate 3. The Queen Elizabeth II oil dock at Eastham was completed early in the year, and has already been described in these columns. The largest scheme on which work was in progress in 1954 appears to be the Mersey Docks and Harbour Board's remodelling of the Langton and Canada docks, a project costing £16,000,000, it is estimated. We have received an account of the progress of this scheme sufficiently detailed to warrant a separate article, which will appear in The Engineer very soon.

Plate 3 also illustrates a reconstruction scheme at the Gallions entrance lock of the Royal Albert Dock. The main alteration to the original design consists of levelling the invert and sills over the width of the lock. The original brick invert arch is being cut out at the sides and substituted by reinforced concrete "knees" placed *in situ*. This work involved very careful procedure and was carried out in isolated, short lengths. The precast concrete block dam mentioned on Plate 3 weighs approximately 15,000 tons. The total fill in the double-skinned, hard-core-filled, steel-sheeted-piled dam amounted to 30,000 cubic yards.

The ground water level was lowered 30ft to 40ft throughout the site by twenty deep wells, discharging about 1500 gallons per minute. The pumps are electrically operated and to meet the possibility of a break in the public power supply, two 280kVA generating sets were installed. Where it was necessary to break through the bottom of the lock, chemical soil consolidation was effected by injection.

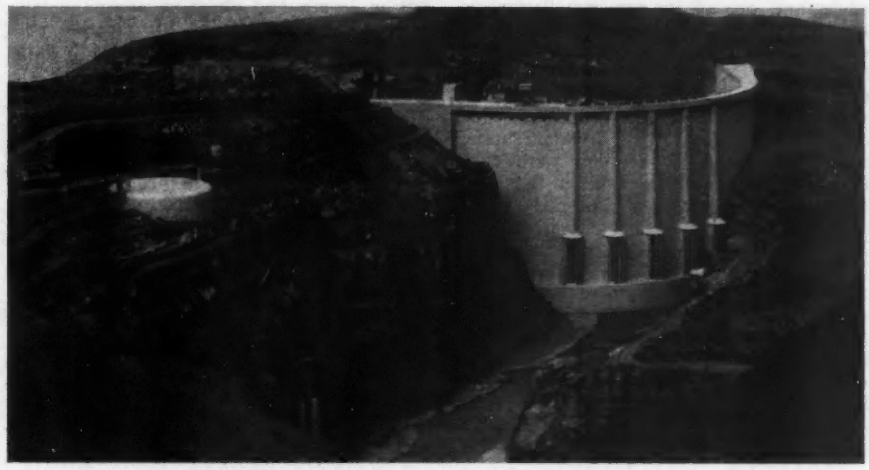
The reconstruction of the sills and the placing of the side "knees" was completed last year, and work was in hand on the reconstruction of the gate quoins, the replacement of loose brick facing by concrete, the reconstruction of culverts in the invert, the building of three new pairs of all-welded steel gates and the replacement of hydraulic chain-operating gate machinery by electrical gear-driven machinery. Provision was also being made for the lock to be dried out in the future if necessary by constructing emergency sills for using the lock gates as temporary dams. The timber leading-in jetties at the river end of the lock were being repaired and new accommodation built for the dock master's staff. The final cost of the work is expected to be about £1,000,000, and completion is expected towards the end of this year.

The Port of London Authority is also carrying out a major work at Tilbury, where a new quay is being built. This work commenced in 1953, and is estimated to cost about £900,000. It is designed to accommodate the largest ships using Tilbury Dock and, in particular, the new passenger vessels now working on the Far Eastern and Australian routes.

The new quay is sited on the west side of the main dock adjacent to the west branch dock, the west side of which has been cut back to give greater swinging room for vessels. The quay is to be 842ft long with a depth of water of 42ft 6in below Trinity High Water and is returned for a length of 240ft at the western end, which will, in the future, form the commencement of one of the quays of an additional branch dock. Construction is of concrete monoliths, 30ft square, containing four cells, as illustrated on page 9. The monoliths are constructed at ground level in sections and are sunk into the ground by excavating in the cells and by placing kentledge on top. The monoliths are being founded on ballast or chalk and their depth has varied from 52ft 6in to 75ft below Trinity High Water. The maximum weight of kentledge used on one monolith has been 1500 tons. The monolith wells and the back cells are sealed with mass concrete; four 18in octagonal reinforced concrete piles are driven between each pair of monoliths to seal the gaps between them. Precast concrete slabs are being placed over the front walls and *in situ* slabs constructed over the spaces between the monoliths. The design includes a subway, which will take all the services. The width of the quay is to be 50ft and it will

incorporate an 18ft gauge crane track as well as railway facilities. The work of widening the main dock to give access to the existing quays for the larger ships has involved the demolition of some 480ft of the original dock wall by blasting and dredging in conjunction with the general dredging of the ground in front of the new quay wall.

Work on all the monoliths was started during the year and the majority were founded. Work on the superstructure was in hand and completion is expected next August. A combined passenger terminal and goods transit shed of approximately 100,000 square feet, which will be in reinforced concrete with shell roof construction, will then be built. A contract for this work will be let in the near future. The work now in progress is under the direction of the chief engineer of the Port of London Authority, Mr. G. A. Wilson, the main contractor being Holloway Brothers (London), Ltd.



A model of the proposed arch dam, 385ft high, at Dokan, Iraq, is shown here. Construction of the dam was started in 1954

Dock and Harbour Works Overseas

British consulting engineers have always had a strong interest in dock and harbour works in overseas countries, and in previous annual reviews we have drawn attention to major schemes of this nature, in the Commonwealth African territories and elsewhere. The entries in our 1954 *Tabular Summary*, mentioned earlier, show that the total value of overseas contracts in progress last year was greater than that of dock and harbour works at home. Of the larger overseas projects, Aden oil harbour will be illustrated in our art plates next week. The examples hereunder are more modest in size, but not without technical interest.

A naval dry dock and fitting-out berth was completed during the year at Karachi for the Government of Pakistan. Work commenced in February, 1952, and the first dry docking took place last June, the total cost of the work being about £1,500,000 sterling. The overall length of the dry dock is 420ft with a width of 60ft at the entrance and a minimum depth of water over the sill at low tide of 14ft. The main excavation was carried out partly in open cut and partly in steel-sheet-piled trenches, to a depth of 40ft below original ground level using the wellpoint system for dewatering the sand. The walls and floor of the dock are in mass concrete, the pumps being housed within the dock walls together with all services ; a dockside portal crane travels on top of one of the dock walls. At the entrance of the dock a warping-in jetty was provided, a steel box pile and timber decking construction being adopted with steel bracing above low tide level.

The fitting-out berth is 600ft long, giving a minimum depth of water at low tide of 22ft. Steel sheet piles were used for the wharf face with concrete piles supporting concrete beams to carry a portal crane. Dredging was carried out by grabbing and by suction dredger with a maximum overall depth of excavation of 35ft. A land reclamation scheme was also carried out to provide an area for the discharge from the suction dredger.

Four vertical spindle electric pumps enable the dock to be completely dewatered within a period of two hours ; operation of these pumps, and all ancillary equipment, is controlled from a central desk in one of the motor rooms. The two electric portal cranes provide a lifting capacity of 15 tons at a radius of 45ft. The floating steel caisson is fitted with timber stems and keel incorporating a rubber seal for contact with the vertical faces of the concrete caisson groove formed in the entry section ; operation of the caisson is by flooding with sea water and emptying with compressed air.

At the peak of construction a maximum of thirty Europeans was employed in the consulting engineer's and contractor's organisations, together with 500 locally recruited plant operators, skilled tradesmen and labourers. The consulting engineers were Messrs. Merz, Rendel, Vatten (Pakistan). The main civil engineering contractor was George Wimpey and Co., Ltd., but there were separate contractors for the dewatering pumps, dockside cranes and floating caissons.

Four new berths were completed in 1954 for the Shell Company of Singapore at its Pulo Bukom oil installation ; they provide 42ft of water alongside. Three of the wharves were built to a novel design illustrated opposite, consisting of a heavy reinforced concrete beam 240ft long by 9ft by 7ft 6in carried on a single line of forward raking high tensile steel piles. The concrete beam gives the line of piles an initial forward deflection which is in effect a " prestress " ; this enhances the capacity of the piles to absorb energy in bending in the opposite direction. A similar design was used at the Rockfort oil berth, Jamaica, which we mentioned in our annual review last year.

The Pulo Bukom structure has already proved its worth, we are informed, for on being struck almost bow-on by a tanker displacing about 20,000 tons, and moving at roughly 2ft per second, the beam suffered only superficial damage by concrete spalling from a small area, and local damage to the fendering. The tanker proceeded on its way undamaged and the berth did not go out of service. Each berthing beam is capable of absorbing the kinetic energy of vessels up to 60,000 tons displacement when berthing at speeds of up to 9in per second. The works, which also included secondary jetty heads as well as mooring and berthing dolphins, were designed by the consulting engineers, Sir William Halcrow and Partners. The civil engineering contractor was Gammon (Malaya), Ltd.

Construction of the Daer dam in Lanarkshire is here shown in progress. The completed embankment will be 135ft high

Water Supply

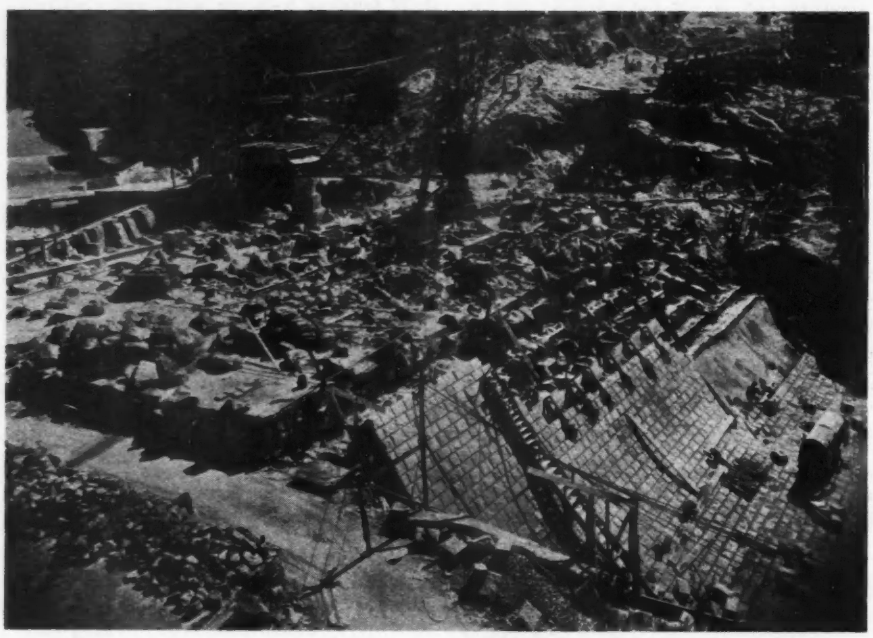
The great majority of the large-scale water supply schemes which were in progress in 1954 were schemes upon which work had been in progress for several years. The Metropolitan Water Board's new works programme is to be noted in a separate

article, and one of its new installations is depicted in Plate 2. The Haweswater aqueduct—one of the largest civil engineering schemes of recent years—for the water supply of Manchester was nearly completed during the year, and the first pipeline is due for completion next April. Water supply improvements for Birmingham were concentrated on the fourth main of the Elan aqueduct, for the reservoirs of this system were substantially augmented when the Claerwen dam was completed in 1952. Constructional work was also in progress on the fourth instalment of the Vyrnwy aqueduct of Liverpool Corporation Water Department. As an illustration of the water supply works of the larger cities, some details are given below of the progress of Glasgow's water supply schemes; these notes are followed by some examples of works which were being built under the direction of consulting engineers.

Since the war an appreciable programme of new works has been undertaken by the Glasgow Corporation Water Department, and from time to time we have described newly completed projects, such as the east main. During 1954, the Clyde tunnel, a part of the new west main, made good progress, as noted in Plate 2. Various newly developed areas around the city are to be supplied from these new mains, and their associated service reservoirs and pumping stations. Work on this distribution system included, for instance, the construction of a 400,000-gallon reinforced concrete water tower at Drumchapel, which was completed early in the year.

The main aqueduct tunnels from Loch Katrine, the source of supply, to Milngavie were brought to their full capacity by the completion of the Endrick and Blane Valley syphon pipes, the last of a series of mains across these two valleys, thus completing a scheme started about a hundred years ago. These last works consisted of the laying of 2¾ miles of 49in steel pipeline across the Endrick Valley, approximately 18 miles from Glasgow and ¾ mile of similar pipeline across the Blane Valley, approximately 11 miles from Glasgow. The pipelines consisted of steel tubes averaging just over 27ft in length and weighing approximately 3 tons 14 cwt each, and the pipeline was lined internally and sheathed externally with bitumen, and jointed with Viking Johnson couplings.

The routes generally traversed farming land, with various road, rail and river crossings. The proximity of the existing series of pipelines, six in number, meant that no heavy loads could be permitted without suitable protection and excavators had to travel on timber mats and rock excavation had to be carried out by compressed air work, blasting being prohibited. The maximum depth of excavation was 20ft, normal cover was 3ft, and the steepest gradient 1 in 3. The pipes were protected by concrete where the cover exceeded 7ft and through the railway crossing and four of the six road crossings, one of which was carried out in tunnel. The maximum head on the Blane syphon is 130ft and on the Endrick syphon 227ft. The contractors were Stewarts and Lloyds, Ltd., for the manufacture and supply of the pipes; Glenfield and Kennedy, Ltd., for the manufacture and supply of the valves; McKean and Co., Ltd., for the pipe-laying in the Endrick Valley and James Miller and Partners, Ltd., for the pipe-laying in the Blane Valley. These works were carried out under the direction of the chief engineer and general manager of Glasgow Corporation Water Department.



Tai Lam Chung dam, part of Hong Kong's water supply system, is being heightened to increase the reservoir capacity of the system. Its final height will be 180ft

Progress of both the Usk dam, for Swansea Corporation, and Daer dam in Lanarkshire, has been noted in previous annual reviews in this journal. Both dams, which were designed by the same consultants, were nearing completion at the end of the year. We illustrate on page 11 the Daer dam, an earthen embankment ½ mile long and 135ft high, giving a reservoir capacity of 5300 m.g., which was in the sixth year of construction in 1954. During the year 320,000 cubic yards of filling were added, bringing the total to 2,250,000 cubic yards, and the level of the work to about 1124 O.D.; the top water level is 1122 O.D. The protective concrete slabbing on the upstream face, and soiling and sowing on the downstream face were well advanced, as were the ancillary works, namely, valve tower and access bridge, spillway, stilling pool and discharge channel. Over half of the constructional work was completed in the treatment works, which are designed for the reservoir yield of 25 m.g.d. The works are being carried out for the Daer Water Board by direct labour. The consulting engineers are Messrs. Binnie, Deacon and Gourley.

During the year, the water supply industry was urged by the Minister of Housing and Local Government to speed up the co-ordinating policy recommended in a White Paper in 1944, which suggested reducing the number of undertakings so as to increase their efficiency. At the British Waterworks Association dinner last July, the Parliamentary Secretary noted that the number of undertakings had decreased by only 200 since 1944, and there were still over 1000. He also stated that the former advisory committee on inland water survey was to be reformed, with a strong scientific representation. These steps result from the increasing use which is being made, over the years, of Britain's water resources, and it is now possible to foresee that limitations of water supplies may be critical in development schemes in the future. Some figures given during the year in a Parliamentary reply illustrate this point. In 1929, the total storage capacity of water undertakings in England and Wales was 119,100 m.g.; in 1953, the corresponding figure was 304,700 m.g.

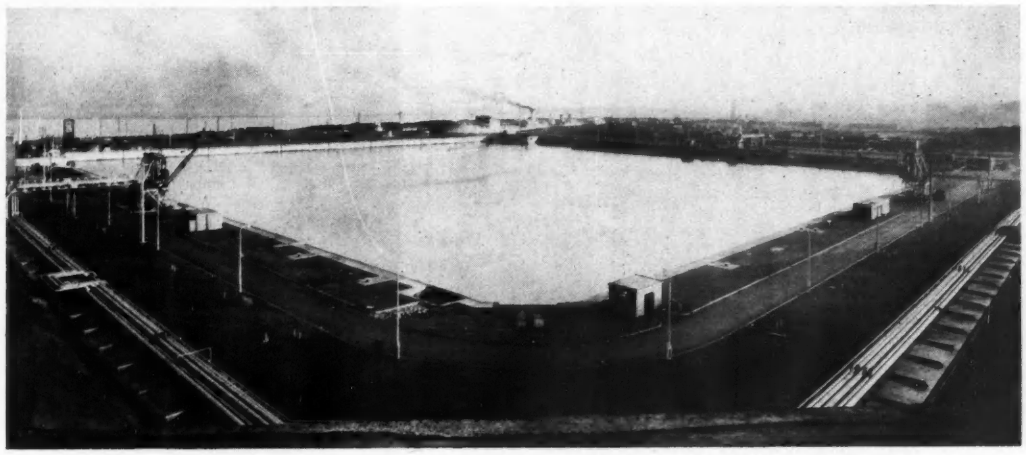
Two Overseas Works

In Iraq, construction work on the 385ft high concrete arch dam at Dokan, on the Lesser Zab River, began during 1954. The main contractor is Société Dumez-Ballot of Paris, whose tender price was £8,817,460. The contract was awarded in February, 1954, and the work is estimated to take just under four years. A model of the dam is illustrated on page 11. The ancillary works include a bellmouthed shaft spillway which joins the 41ft diameter diversion tunnel, and a gated spillway with 36ft diameter tunnel. The pilot heading of the 1100ft long diversion tunnel was completed in November. A thin arch concrete cofferdam 100ft high will be constructed this year. A considerable rock-sealing programme is envisaged, and the joint subcontractors for this work are the Cementation Company, Ltd., and Sondages Injections, Forages of Paris. Subcontracts were also awarded to V.O.E.S.T. of Austria, for the steel tunnel linings and penstocks; to M.A.N. of Germany, for the emergency gate and crest crane, and to Neyrpic of France, for 7ft 6in diameter twin outlet and guard valves. The reservoir will have an area of 115 square miles at top water level.

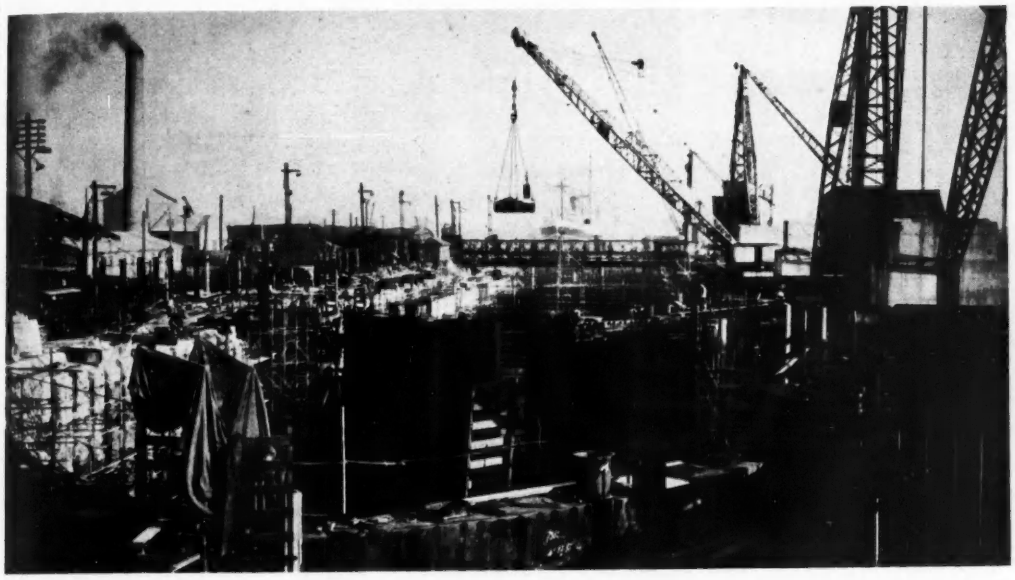
Development of the headworks of the Tai Lam Chung water supply scheme for Hong Kong to their full capacity was also proceeding during the year. This work involves completion of the main masonry faced concrete dam to its full height of 180ft and length of 1200ft. The raising of the top water level by 50ft necessitates the construction of a dam approximately 600ft long across an adjoining hollow, and also of three subsidiary dams. These four additional dams will all be earthen embankments with concrete filled cut-off trenches and articulated concrete core walls. The raising of the water level will increase the capacity of the reservoir from 1150 m.g. to 4350 m.g. At the end of the year, the concreting was carried up to approximately 20 per cent of the height; the work is shown in progress on the main dam in the accompanying illustration. The consulting engineers for both the Dokan and Tai Lam Chung schemes are Messrs. Binnie, Deacon and Gourley.

(To be continued)

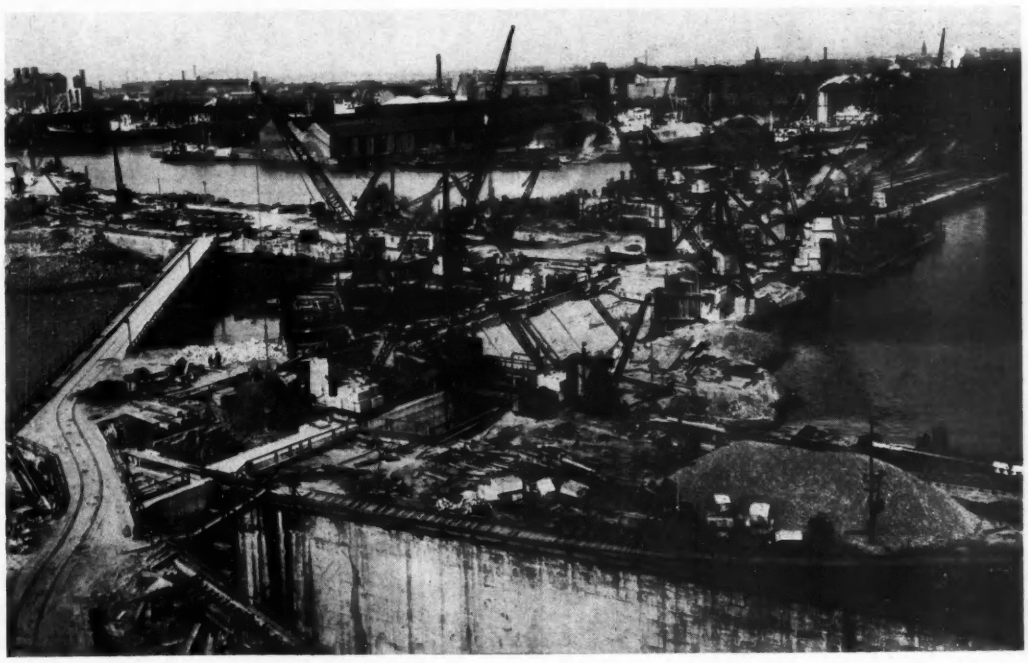
DOCK AND HARBOUR CONSTRUCTION IN 1954



The Queen Elizabeth II oil dock at Eastham was opened on January 19, 1954. It has four tanker berths, the dock being very approximately square in shape, with an entrance lock 807ft long and 100ft wide. Conveyor belts were used to carry the excavated material from the dock to the spoil tips, and to carry concrete, from a central station beside the entrance lock, for emplacement in the mass concrete dock walls. The dock was built under the direction of the chief engineer of the Manchester Ship Canal Company; the main contractor was Sir Alfred McAlpine and Sons, Ltd.



The Gallions entrance lock of the Royal Albert Dock was built between 1885 and 1887 (556ft long by 80ft wide by 36ft centre depth below Trinity high water) and is now being repaired and altered. The inverted brick arch forming the invert is being replaced by reinforced concrete "knees" at the sides of the lock to give level invert and sills. The lock has been dried out with the aid of a precast concrete block dam at the inner end, and a double-skinned hard-core-filled steel sheet piled dam at the outer end, and the ground water lowered by twenty deep wells. New lock gates are to be installed. The work is being directed by the chief engineer, Port of London Authority; main contractor John Mowlem and Co. Ltd.



A major scheme of reconstruction to give a modern river entrance lock 825ft by 130ft in size is in progress at the Langton and Canada Docks at Liverpool. Our illustration shows the old 100ft Canada lock in the foreground, and a trench for a mass concrete wall founded on raking piles in the middle distance, with the cofferdammed entrance of the Canada-Brocklebank Passage to the right of it. The scheme includes reconstruction of this passage, and removal of the old lock in the foreground. The new entrance lock will be to the left of the area shown in this illustration and the left foreground is eventually to be filled. The scheme is directed by the chief engineer of the Mersey Docks and Harbour Board, and is being built by direct labour

PRODUCTION OF "VISCOUNT" AND "BRITANNIA" AIRCRAFT

Vickers "Viscount 724" (left) for T.C.A. It has the uprated "Dart" turbo-propeller engines, giving 1697 e.h.p. each, which boost the maximum payload to 12,800 lb with a range of 1450 miles. It carries from forty to fifty-nine passengers and has an all-up weight of 60,000 lb. Production of this version is shown in the illustration below left at Hurn, where an output of about five a month is planned this year and ten next. It can cruise up to 25,000ft at 318 m.p.h. The slightly larger "800" series announced with the same engines will have an optimum direct operating cost of only 1·25d. per passenger-seat-mile, compared with 2·15d. of the "Dakota"

Bristol "Britannia" Mk 100 aircraft in assembly at Filton (below right). It is fitted with the "Proteus 705" turbo-propeller engine giving 3780 e.h.p., has a cruising speed of 340 m.p.h., a payload of 15,000 lb for its maximum range of 5270 st.m. or 25,000 lb over 4100 st.m., and has accommodation for sixty-three to ninety-two passengers. All-up weight is 140,000 lb. Final production rate at Filton will be twenty-five a year. Short Brothers and Harland, Ltd., is also to produce twenty-five a year at Belfast. The larger Mk 300 series is to have the "Proteus 755" engine of 4150 e.h.p., the range with payload of 30,000 lb being 4500 st.m., and maximum range 6100 st.m.

Aeronautics in 1954

AERONAUTICAL security regulations shield, quite rightly, the advances in airframe and engine development, and they aim to disguise changes in tactics and policy; but, regrettably, if their imposition is to be consistent and effective, failure as well as success in design and planning must be alike concealed. There is, as a consequence, perhaps, the very real danger that friend and foe become equally deceived or confused; unwittingly indecision and bad decisions can go too long uncorrected, rejection can be delayed.

In avoiding technical abuse the dictates of secrecy tend to become arbitrary and cease to be flexible or selective enough to discriminate between a good and a bad or an old and a new engine or airframe or, for instance, between the components of an engine itself. Thus, by publishing little more than the overall dimensions of a gas turbine very few can assess its merits. Not only how good is our best, but how bad is our worst, can never be revealed. The distinctive features that make one engine design better than another may comprise no more than the particular metal of which a part is made, the form of a blade profile or the method by which it is cooled, the presence of a seal here or a bearing there, and other subtleties of engineering details—all of which might be simply disguised in a drawing. Again the general lay-out of an engine may conform to designs and diagrams to be found in the books of any technical library. Yet drawings of most of these prime movers are still subjected to the unyielding darkness of total secrecy.

Airframes are no more fortunate in their treatment. The concept of security as applied here regards it as necessary to conceal not only details and the performance of a new advanced aircraft but also those of one obsolete on most standards; or to conceal for as long as it can the performance of a prototype which, for instance, occasionally loses its tail or has equally disastrous control failures, or insufficient range or pilot visibility, is poorly manœuvrable at altitude, discharges its armament like a shorn-off shot gun or is simply too slow. Other nations speak more freely of their failures and have readily admitted the existence of one or another of these characteristic evils as having attended at one time the development of their transonic and supersonic aircraft, and they are often as frank about their remedy.

Even more closely guarded is the development of the guided missile, the most complicated and unpredictable weapon carrier in the world's armoury, and known to be still labouring against unprecedented difficulties. The whole concept of "insuperability" in relation to expense with regard to some of the fundamental problems has been perpetually discarded during the course of its development, yet in spite of the fact that it is at least expendable and therefore not so handicapped as are piloted supersonic aircraft, by the huge problems of providing a reasonable structural life under transient load and temperature cycles, there are not many even now who express confidence in committing a nation's armament to them. Yet the potential remains such that all other weapons are constantly threatened with obsolescence.

The other aspect of rearmament which security quite naturally suppresses is production. The only official information on this subject relates to the announcement nearly three years ago of a super-priority production programme concentrating on six different fighter and bomber aircraft, all of which were designed shortly after the last war and consequently were subsonic machines. Until recently the only additional official information has suggested that this programme has been effective and that each machine in its own functional role was superior to any other.

It was probably common knowledge to all major powers that with the advent of the gas turbine and in view of its development potential, each new airframe and even its specification was threatened with obsolescence before production could proceed. This could be no argument, in itself, for producing no aircraft at all, or, little better, for producing a string of modified prototypes one by one, each different from the other. The first essential, therefore, in providing some minimum defence was to accept what was clearly inevitable and expedite at least the batch production of essential classes of aircraft, trusting that limitations and snags for which no doubt there were subsequent cures, were no worse than those of aircraft it might encounter in any immediate outbreak of war. Such has been the policy adopted by America and Russia, and the announcement of our own production programme, late as that seemed then, was at least in step.

With guided missiles it was stated nearly two years ago that over 100 firms in this country were then engaged upon their manufacture or development, that it had become in fact an industry within an industry. Some old types were exhibited at Farnborough last year, but there has been no public demonstration of a guided missile yet in this country or any indication that one is yet ready for service. It is reported from America that a total of six missiles in this category are in service.

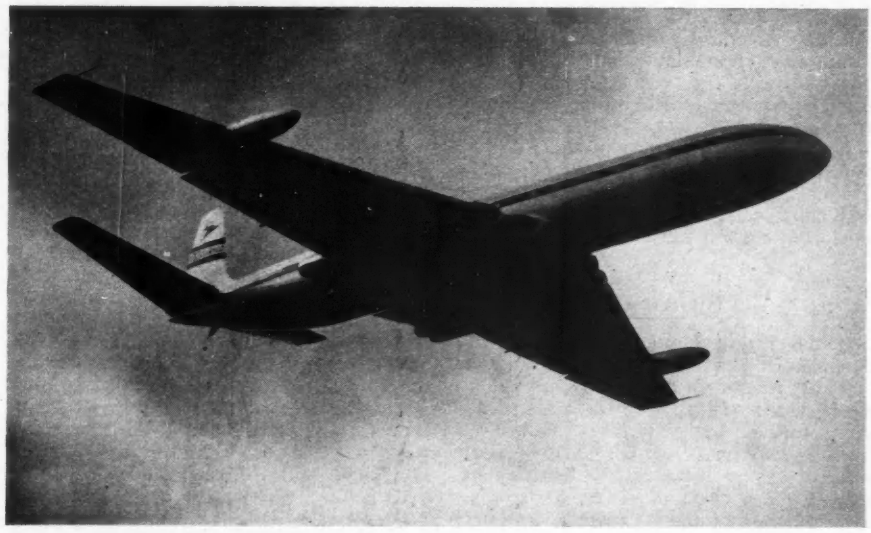
Such, then, is the degree of total secrecy imposed alike upon the design, development, production and the policy of the whole aeronautical industry. It invites the question of how many people indeed are properly informed of the present state of aeronautical development in this country, and how it stands at least in relation to America.

Design and Production

Having introduced this particular review of aeronautics with an appraisal of security regulations, it is relevant to note the growing feeling of disquiet throughout the nation which has found expression in many quarters, including the House of Commons. Critics have been concerned mainly with the failure to equip the Royal Air Force and the Royal Navy with at least some of the high subsonic aircraft which have been in super-priority production. A figure of less than sixty is freely quoted for the number of swept-wing interceptors in service and all the four-engined medium jet bombers put together would not form a squadron. These figures if true would imply that after nearly ten years' development the air strength of this country is still nearly entirely dependent on airframes obsolescent even by German war-time standards.

Last month in response to a question in the House of Commons, the Prime Minister explained the system of co-ordination between the Ministry of Supply, the Air Ministry and the Admiralty for the obtaining of aircraft. It was then maintained by a Member that an "appalling delay" existed in the delivery of aircraft and asked if it was not time that the system was overhauled. In his reply, the Prime Minister explained that the issue was very complex and had raised in his mind whether a special Ministry should be re-created to deal with production. Happily, he continued, "the delays . . . through accidents, through too few prototypes and through unfortunate and tragic events here and there, will not work out to our disadvantage." To another suggestion, that these events certainly had resulted in a considerable loss of public money and that a committee should be set up to survey the state of the whole aircraft industry to see whether the public is getting value for its money, the Prime Minister replied that the occasion of the Estimates would be an admirable time for raising this issue.

Questions of equal urgency might also be asked concerning the design of both bomber and fighter aircraft. Whether, for



The "Comet III" with Rolls-Royce "Avon" engines of nearly 10,000 lb thrust each

instance, after three years of evaluation, it has been decided which most nearly satisfies the specification to which the "Vulcan," "Valiant" and "Victor" bombers were designed, whether it is still essential to continue production with all three rather than to concentrate production on one or two; whether we can still be satisfied that these aircraft are superior to the six-jet Boeing "X47," which has been on quantity production for two years and has amassed thousands of hours of squadron service; whether, in fact, we can still be convinced that the quantity production and the performance of a bomber is best served by the British concept of shrouding the engines and fuel in the wing rather than mounting the engines and some of the fuel externally from pods as favoured by the Americans.

With fighter aircraft, the comparatively sudden emergence of the "F100" regime of truly supersonic combat aircraft, which, it is reported, have been placed in quantity production, was noted in our leading article* which also traced the supersonic research programme in America dating from 1946 and leading up to them. As supersonic flight development has only just commenced in this country with the Fairey and English Electric Company's machines, the question arises as to how long it will take Great Britain to catch up in this sphere without soliciting American assistance, or whether, for instance, an interim exchange of airframe "know-how" for engine "know-how" could be arranged to help bridge what would appear to be a gap.

If American confidence in the "F100" series is justified there is now raised the further question of whether the subsonic "Hunters" and "Swifts" will now reach squadrons much in advance of them.

Civil Aviation

If the British aircraft industry was to command a place in world aviation in the face of American domination it had to establish a lead in the development of aircraft propelled by gas turbines. It was not likely to survive otherwise. The propeller turbine version became the joint responsibility in the first case, of Vickers Armstrongs, Ltd., which made the "Viscount" airframe, and of Rolls-Royce, Ltd., around whose "Dart" engines the craft was designed. The more onerous responsibility of developing a pure jet airliner was undertaken with great enterprise by De Havilland Aircraft, Ltd. Last year witnessed both the total world-wide success of the former project and the tragic but it is hoped temporary failure of the "Comet" pure jet airliner.

Brief details are given of the "Viscount" on plate 4, its outstanding economy being shown in the caption, and little more will be said of it here than to record the fact that nearly 200 firm orders exist for it, eighty-three of these in North America.

The "Comet"

It is hard to find a parallel for the "Comet" disasters and the investigations which led up to the Court of Inquiry.

The "Comet" inquiry emphasised several disturbing facts concerning aircraft structures. It was evident that the complex nature and extent of the external loading to which an aircraft is exposed in flight is far from being completely determined; that the stress distribution within the frame, in so far as this was ascertained on the "Comet," was different to that predicted by existing data in at least some of the primary fuselage structure; and that the physical properties of some of the materials used when exposed to combined cyclic temperature and loading conditions where not known with certainty, at least over the range to which they were likely to be experienced in aircraft which cruised as high as the "Comet." Thus, under these circumstances even if the phenomenon of fatigue were completely understood the fatigue life of an airframe would still be one of conjecture.

The intention in this country, therefore, to subject all pressurised aircraft to a structural test programme simulating the flight loading of an aircraft to destruction as was done with the "Comet" would seem, with present knowledge, wholly necessary. Even this stringent and expensive requirement cannot fully realise the actual loading conditions, for it is not contemplated—neither is it possible on the whole aircraft, using water as the testing fluid—to simulate the temperature gradients which develop in a take-off/landing cycle. This may itself prove to be a particularly bad defect of the test, especially where relatively new structural bonding techniques are used in which certain resins are notoriously unstable at temperatures not greatly removed from those likely to be experienced. There was the fact that with the two "Comets" which crashed in the Mediterranean Sea failure of the structure had occurred after only one third of the life predicted by the Farnborough tank test. Although it was explained that scatter of this order in fatigue testing was not uncommon with the fatigue life of similar structures, this discrepancy did not convincingly remove the possibility that some other factor was operating to disrupt the stress distribution in the structure.

The influence of transient temperature gradients on aircraft structures, having only recently assumed any importance with the advent of supersonic craft has become the subject of a growing amount of investigation and of technical literature. It has been shown, for instance, with an elementary wing skin/web configuration that a transient temperature differential between the skin and the web of only 100 deg. Cent. could create strains which when superimposed upon those due to the flight loading are of an order capable of exceeding the safe yield strains and consequently greatly reducing the number of reversal cycles to failure. A transient temperature gradient of this order could be set up twice in each take-off/landing cycle of a high flying aircraft.

Whether or not the weakening of the "Comet" fuselage was influenced by temperature conditions, the cause of that disaster was explosive decompression—it blew a large section of the fuselage into small pieces. The damage has been likened to that which might be caused by the internal explosion of a 100 lb bomb, and that the consequences could be so violent or whether they depended on the nature of the puncture, if previously realised, had not been emphasised.

It is not likely that fatigue will be given the chance to explode another aircraft as it did the "Comet" and as it might also have done with other pressurised aircraft both here and in America. One recalls particularly the accidents much earlier to the "Tudor" aircraft "Star Tiger" and "Star Ariel," both of which disappeared unaccountedly over the sea and in ominously similar circumstances to the "Comet." It might well be that a tank fatigue test on an A. V. Roe "Tudor" aircraft, which was Britain's first pressurised passenger aircraft to enter service, would now prove illuminating. Fatigue considerations, however, are not the only factors which can induce explosive decompression in the more highly pressurised aircraft. What are the chances of it being punctured by an ejected turbine blade or an even larger piece of its high-speed rotary system, or of a propeller fragment? Or what are the consequences of the failure of a window, an emergency hatch or any other of the seals, valves and removable panels on which the maintenance of the pressure differential depends? These are no doubt amongst other factors affecting the design of a high flying aircraft, likely to receive more close attention.

Looking back on the development of aircraft, it is not difficult to see that in attaining higher speeds they have progressively become more complex, each complexity inevitably introducing its own order of hazard which together on some calamitous occasion select some unfortunate aircraft upon which to cast their cumulative might. Some crept in unobserved and for a time have exacted their own toll. Fatigue has always lurked in one guise or another. Undercarriage legs were prone either together—or singly, which was worse—to stay down or stay up or falsely to indicate that they had done so. Hydraulic systems lost their fluid, and without flaps or undercarriage, some aircraft have in that unhappy condition landed or crashed. Variable pitch and, later, constant-speed propellers showed a likeness for slipping into extreme pitch, and the more recent reversible pitch propeller has caused at least one fatal disaster by reversing on take-off. Electrical failures were soon to manifest themselves over the whole range of auxiliary services and controls. De-icing equipment, pitot head heaters, blind flying aids and automatic pilots have all failed in their time when they were most needed, and many are the occasions when pioneers with new radio aids have lured their craft into the overcast and then experienced a stubborn silence. And with such complication it was not surprising that sometimes too the pilot failed.

All these factors have exercised their terrors, but the pattern of malfunction has usually been determined, and either by modification or the duplication of essential elements (with the exception of the pilot!) they have lost their sting.

In a great measure the relative freedom which post-war civil aircraft now enjoy from many of these troubles is owed to military aviation which bore the brunt of their enforced and accelerated development during the last war, and as has perhaps been overlooked, with heavy loss of life. Nevertheless, whilst the possibility of any single failure is being constantly reduced, the number of possible failures goes on increasing. The aeroplane becomes an immensely more useful vehicle, but it does not become a safer one.

The "Comet" is just another aeroplane in this evolutionary pattern, and it must very soon be flying again. It was thought to have waged successfully its major battles in establishing the jet airliner. That it succumbed to what seemed a stray shot made its failure all the more bitter. But to achieve an extra 200 m.p.h. over its contemporaries it must cruise at heights greater by 10,000ft to 20,000ft and at temperatures many degrees colder, and both increments may prove more critical upon its overall economy than was anticipated. In any event its highly pressurised cabin is a consequence of the former requirement, and hence the civil aircraft commences to wrestle with just another hazard.

* The Engineer, September 10, 1954.

Shipbuilding and Marine Engineering in 1954

No. I

THE year 1954, taking an overall view, was fairly uneventful, and the shipbuilding industry continued to be prosperous, but signs were not lacking of the coming of change, alteration in tempo and, indeed, the red light of the impact of much stronger and more intense competition was clearly visible. This took tangible shape with the placing of orders abroad, by both foreign and British shipowners, for ships which could reasonably have been expected to be ordered in Great Britain. That such a position would be reached was not entirely unforeseen by those who were not dazzled by the extraordinary conditions obtaining in the immediate post-war years, and who indulged in forward thinking with regard to the long-term planning for the continued prosperity and stability of the shipbuilding industry.

In 1952, when the total tonnage on order in the United Kingdom had attained the enormous figure of 7,000,000 gross tons, following the unprecedented spate of orders in 1951, amounting to over 4,000,000 tons, several shipbuilders stressed the need to put the industry's house in order. This they emphasised was an essential step in the organisation of the industry to meet the inevitable resurgence of foreign competition. It was also a necessary move towards attaining a state of preparedness against the time when the heavy demand for tonnage, owing to the need to make good war losses and to the damage sustained by shipbuilding facilities abroad, would in due course become stabilised at a lower and more rational level. About midway through 1952 the flood of orders, not unnaturally, began to diminish, but the total for the year amounted to 1,205,000 gross tons. However, the flow of orders continued to follow a downward curve in 1953, and the final total for that year of 520,000 tons confirmed that the post-war era of heavy demand for tonnage to rebuild merchant fleets had come to a close.

During the first half of last year the volume of orders continued at a low level and in the third quarter orders practically ceased, so that by September 30th the total had only reached 282,000 tons, and the indication was that if there was no improvement the final return for the year would be very low indeed. However, during the last quarter there was a sudden spurt in the placing of orders, and it was estimated that the final total for the year would be about 500,000 gross tons, an amount approximately equal to the 1953 returns. With such a small amount of new work being placed, for the second year in succession, the effect was apparent in the state of the order books, and the total dropped from 850 ships of 5,500,000 gross tons to about 760 ships of 4,250,000 tons, valued at approximately £475 million at ruling prices. Apart from the effect of the level of new orders and of work completed upon the back log of tonnage, cancellations amounting to nearly 300,000 tons also played their part in reducing the grand total. Again, as in past years, about one-third of the ships on order was to foreign account.

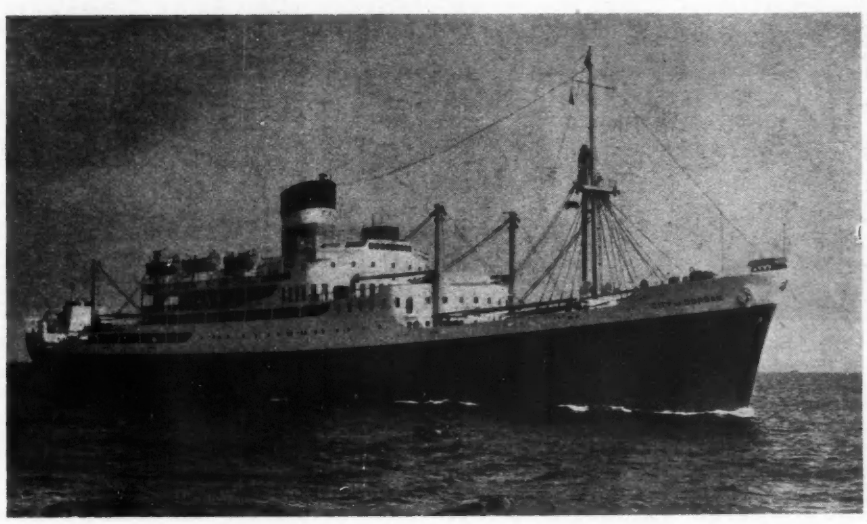
Although considerably reduced, the large total of orders in hand was still representative of boom conditions and bore no relationship to those normally obtaining in the industry before the war. Taken overall the figures indicated something approaching three years' work. However, since oil tankers continued to represent over 50 per cent of the tonnage under contract and since in round figures one-third of the yards are responsible for building two-thirds of the output, while the remainder build the balance, then it was evident that while deliveries of tankers were delayed, other classes of ships could be relatively quickly completed. Indeed, many yards building the smaller class of ship were not in a very happy position with regard to the almost immediate future and were ready to welcome orders to keep the berths filled. It is of interest to note that whereas 169 ships were ordered in 1953, the number was over 250 in 1954, which indicated that, since the tonnage for both years was of similar amount, many of the ships ordered were of smaller size. Indeed, the total included many dry cargo ships and a number of small vessels, thus both the non-tanker yards and small builders received help.

The latest returns available from Lloyd's Register of Shipping, that is up to September 30th, show that the total tonnage under construction at 2,058,000 gross tons was a reduction of 130,000 tons during the previous twelve months, but still represented 37 per cent of the world tonnage because the world total also was reduced, the comparative amount being 360,000 tons. It is encouraging to note, however, that the amount of work completed took a stride forward to 1,503,000 tons from the annual rate of production of recent years, which had been limited to a maximum of approximately 1,300,000 tons by reason of the shortage of suitable steel and out of step fulfilment of orders. The actual total of completions for the previous twelve months was 1,211,000 tons, so that the new level was an increase of 292,000 tons. The tonnage commenced improved slightly and the tonnage launched advanced by 102,000. However, the returns for the twelve months amount to substantially the same percentage of the world total since the amounts of tonnage commenced, launched and completed in the rest of the world also showed an increase.

The general statement regarding the state of shipbuilding throughout the rest of the world was not reflected in the returns of individual countries. The expansion noted in German building in 1953 was continued in 1954 and that country was our leading competitor with 12·2 per cent of the world total. Holland, Sweden, France and Norway also achieved increased percentages, while those for Japan and the U.S.A. were considerably reduced.

While the bulk of the ships built in Great Britain was for British owners, nearly 33 per cent were for registration abroad and the corresponding figure for the rest of the world was 41 per cent. This percentage varied considerably between different countries. In Germany and Sweden the tonnage under construction for export was 69 per cent and 59 per cent respectively, while the figure for Japan was 95 per cent, and these figures may be taken as an approximate guide to competitive strength, due regard being paid to the fluctuations of the requirements of the home market of each country.

As in previous years, oil tankers continued to represent the greater part of the tonnage under construction, the actual amount being 53 per cent, 40 per cent of which was for foreign account. In comparison 96 per cent of the oil tankers under construction in Germany, 60 per cent of Sweden's output and practically the whole Japanese tanker building was for export. With such a large number of oil tankers under construction the order book presented an unbalanced appearance, and this was reflected in the order books of individual yards. Of the 2,058,000 tons building the following represents an approximate division of the tonnage among the various classes of ships :—Passenger and passenger-cargo liners, 10·1 per cent ; cargo liners, 24 per cent ; cargo tramps, 8·5 per cent ; oil tankers, 53·1 per cent ; the remaining 4·3 per cent consisting of colliers, coasters, &c. With the addition of ships preparing to those under construction the total became 3,638,000 gross

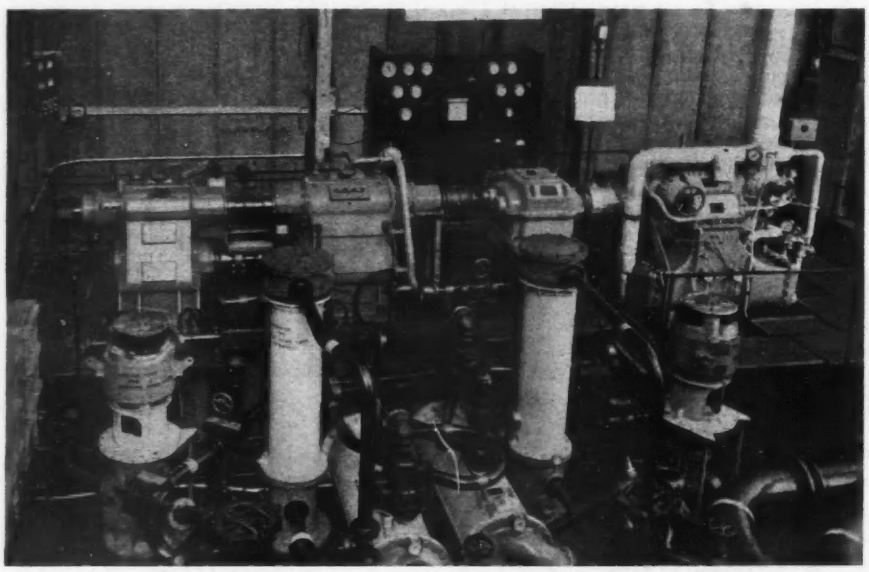


M.V. " City of Durban " is the last of four passenger and cargo liners built for Ellerman Lines, Ltd., at the Walker Naval Yard of Vickers-Armstrongs, Ltd. The following are the main particulars :—Length between perpendiculars, 500ft; breadth moulded, 71ft; depth moulded to upper deck, 41ft; draught loaded, 28ft 6in; deadweight, about 11,300 tons; 106 passengers, five cargo holds, three 400kW diesel-driven generators, two six-cylinder Hawthorn-Doxford oil engines developing a total of 12,650 b.h.p. at 115 r.p.m., and giving a loaded service speed of 16½ knots

tons and the corresponding group percentages were 6·5, 27·3, 8·2, 54·1 and 3·9. These returns indicated a reduction in liner tonnage and an increase in cargo liner building with a slight increase in oil tankers.

The increase in the tonnage completed was not attributable to a higher production rate per man, but was due entirely to the improved steel position. This improvement enabled building to proceed more smoothly and the labour force to be used more efficiently, there being less time wasted due to hold-ups in steel supplies. With an increased rhythm of production some economies no doubt resulted because of the better use of machines and therefore a better return on capital investment. Large sums have been spent by shipbuilders since the war on modernising and improving their plant, but they have derived very little benefit owing to the continued shortage of steel, which caused the 20 per cent. This shrinkage underlines the dangers of the situation to the national interest, especially when thought is given to the large earnings of our shipping.

Modification of taxation demands, fixed prices and quicker delivery, were the three main points emphasised by many shipowners at launches and other functions during the year. Although the investment allowance was welcomed and meant some easement it was not enough to solve the problem of tonnage replacement which is of a continuous character since ships are a wasting asset. About 11 per cent of our merchant fleet is more than twenty years old and a further 8 per cent is approaching that age so that ordering of new tonnage is essential if the merchant navy is to be maintained in a reasonable state of efficiency and at a level adequate for the needs of the country which has to import at least 60 per cent of



Back-to-back test on A.V.G.R.A. first reduction hardened and ground gears

industry to work at well below its maximum capacity.

British shipping is of complex structure, consisting of a fleet containing ships ranging from the humble coaster to the ocean liner, ships both old and new, fast and slow, but all contributing largely by their earnings to the balance of payments. Shipping's share was £221 million in 1952, the last year for which a return has been made, and the level of employment of ships during 1953 and 1954 indicated that the shipping services had earned at least as much and probably more than in 1952, although the dock strike, no doubt, had an adverse effect on the 1954 earnings.

It must not be forgotten that shipping is not a sheltered industry but has to face severe international competition, some of which is unfair by reason of certain countries favouring their own merchant marine by the introduction of preferential port charges, consular charges and other methods of flag discrimination. Such practices set at nought the results of enterprise and years of hard work and so expedite the reduction of the size of the British merchant navy and thus its earning power, with a corresponding damaging effect upon the national economy. Even without such artificial constraints Britain's share of the world tonnage has been steadily shrinking; it had fallen to 26 per cent in 1939 and since the war the trend has continued and the present amount is under its food and much of its raw materials. This constant need for renewal poses questions difficult of solution to the shipowners, for with more than half the profits being absorbed by taxation the remainder are inadequate to finance new building against a background of rapidly rising costs. For it is not enough to set aside depreciation allowances based on first costs. Higher first cost means that the ship has to earn at a proportionately higher rate in order to make provision for maintenance charges and that involves higher freight charges, a point which has to be considered if the rates are to remain competitive. Clearly, further concessions are necessary if the dictum of the Chancellor of the Exchequer to invest in success is to have any meaning.

Fixed prices appear to be a remote possibility, for although shipbuilders also favour fixed prices it is an absurd commercial risk under present conditions of delayed delivery. After all, the shipbuilder is an assembler of an end product and as such must absorb the costs passed on by a long line of suppliers and this position plus recurring wage demands makes the cost plus system of costing almost inevitable. In the final event the shipowners have had to carry the whole of the risk and order ships without knowledge of the final price, an intolerable burden which is becoming increasingly difficult to carry under fiercely competitive trading conditions. To achieve fixed contract prices the co-operation of all suppliers is needed, in particular the abandonment of the present policy of stipulating the cost to be that ruling at the time of delivery. Considerable help towards cost stability can be given in the shipyards by both the management and the workmen. If wages are to be maintained then efficiency must be improved, for as already mentioned, a better flow of steel results in running economies, but the installation of new machines and the introduction of new techniques are not in themselves effective unless the trade unions co-operate by sweeping away out-of-date demarcation rules and by adopting a realistic attitude towards the position as it is to-day. It must be appreciated by all that it is important to maintain our external trade by possessing an adequate fleet and that anything less than this means a contraction in our economy matched by a fall in our standard of living.

There is no intrinsic merit in a large order book. In fact it is a danger in that it engenders a sense of security and a lack of any sense of urgency and the need to be efficient. This applies particularly to those who have been employed in the industry only during the years of prosperity. No one wants to see the return of the old trade cycles but it is essential for the continued prosperity of the industry that the cost of ships be such that they can attract orders, not only from British but from foreign owners. The capacity of our yards is such that a share of orders from abroad is necessary, and that means competition with Continental establishments where it has been noted that both individual and overall output was high last year, so that less overtime was worked ; labour was used economically, there being no rigid demarcation rules and no overmanning ; a high degree of prefabrication and preassembly was employed ; there was a general tendency towards fixed prices ; early delivery was quoted, and there was co-operation between unions and management based upon a realistic appreciation of economic conditions. Similar remarks can be applied to the ship repairing business for many firms on the Continent are in a strongly competitive position, being comparatively free from restrictive labour practices. This latter state of affairs plus other factors means that full advantage is taken of new techniques with a resultant saving of time so that repairs can be completed quickly and the ship returned to service at an early date.

Turning to the question of delivery dates, there is no doubt that, in the main, the spate of orders in 1951 and 1952 created the situation of long deliveries, of which the shipowners complain. The years of restricted delivery of steel have been a contributory factor towards prolonging the situation, and the only solution is higher output, such as occurred last year with the easing of the steel position, so that the order book can be run down and reasonable delivery dates quoted. Once this state of affairs is achieved shipbuilders should be in a position to abandon safety first tactics and offer fixed prices.

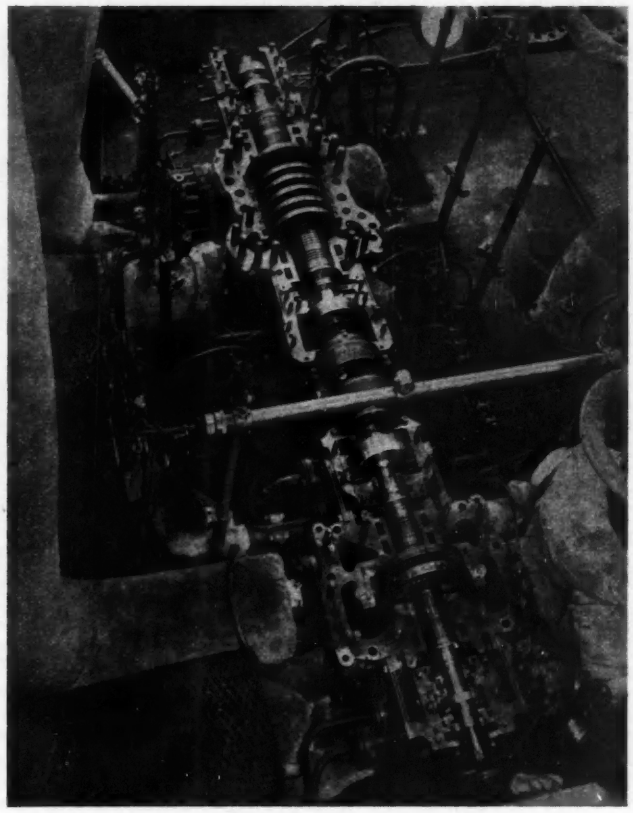
The low level of freight rates obtaining during the first half of last year, the index number being under 80, taking the basis of 100 for 1952, did not encourage owners to place orders, indeed many barely covered expenses and were unable to add to replacement accounts. However, in the later months of last year the index number rose to above 110, but in assessing the effect of this increase upon the possible placing of orders, due regard must be paid to the considerable increases in costs which have occurred since

1952, so that the index requires to rise to higher levels before the leeway is made up.

Research and Development

The many problems associated with ship construction and resistance and the improvement in design of propelling and auxiliary machinery have continued to be the subject of the research activities of the British Shipbuilding Research Association, under its director, Dr. Livingston Smith, and of Parsons and Marine Engineering Turbine Research and Development Association, under its director, Dr. T. W. F. Brown.

April 29th marked the tenth anniversary of the incorporation of B.S.R.A., which is one of the research associations in the Government scheme and assisted financially by the Department of Scientific and Industrial Research. The second five-year period, which is the basis upon which assistance is given, ended on March 2nd of last year and during the year the working of the Association was reviewed, in every aspect of its activities, with a view to negotiating new terms. Those concerned, including the D.S.I.R., expressed satisfaction with the progress made, as shown by the investigation. Due to the extremely wide range and nature of the problems to be solved, which involve many branches of science, much of the research work is carried out extra murally under contract. Any other method of working would have meant the construction of laboratories, equivalent to the N.P.L. on a small scale, at considerable cost and at the expense of duplicating existing experimental equipment and straining the available supply of scientific manpower. The policy adopted had the national advantage that heavy capital outlay was avoided while the use of existing facilities and services ensured that specialist knowledge, in many fields of science, was enlisted to solve shipbuilding problems. However, one of the main activities of the Association is obtaining data from ship trials and from ships in service at sea.



High-pressure, high-temperature steam turbine and steam brake with top half of casing removed

Last year was particularly successful, in that the work on a large number of research items was sufficiently advanced so that research reports could be issued. These totalled thirty-seven, a total greatly in excess of any previous year, and were of especial value, since it is not the practice of the Association to issue progress reports. In addition to the reports, eleven technical memoranda were published and eleven papers, incorporating the results of research work, were read before several of the technical societies.

The items forming the research programme fall into five main groups, namely, hydrodynamics, structures, machinery, performance and vibration. The work on hydrodynamics has for its object the study of the resistance of the ship's hull and appendages and the propulsive efficiency of propellers. This involves the carrying out of experiments in ship testing tanks, and Dr. Smith and Dr. Conn represented the Association at the International Towing Tank Conference, which was held in Scandinavia in August last.

Work on the "Lucy Ashton" was completed last year and Mr. H. Lackenby, M.Sc., presented, before the autumn meeting of the Institution of Naval Architects, the third paper in the series, "B.S.R.A. Resistance Experiments on the 'Lucy Ashton,'" which was concerned with the ship model correlation for two different twin-screw shaft appendages, namely, bossings and shaft brackets. An abstract of the paper appeared in issues of THE ENGINEER dated October 8th and 15th. Work proceeded on the preparation of a fourth and final paper dealing with certain subsidiary tests and including a section devoted to the effect of fouling on resistance. In a number of tanks work was continued on the methodical series using models of ocean going merchant ships, including investigations into the effect of variations of the hull coefficients, the movement of the centre of buoyancy, draught and propeller diameter. Two papers dealing with work were read before the spring meetings of the Institution of Naval Architects, namely, "Model Experiments on a Series of 0·65 Block Coefficient Forms. Part I.—The Effect of Variations in LCB Position and Bilge Radius on Resistance and Propulsion," by N. V. Almy and G. Hughes, D.Sc., Ph.D.; and "Model Experiments on a Series of 0·65 Block Coefficient Forms. Part II—The Effect on Resistance of Variations in Breadth-Draught Ratio and Length-Displacement Ratio," by J. M. Ferguson and M. Meek, B.Sc.

Consideration was also given to smaller ships and special craft and during the year members received a report giving the results of research into the resistance of dredger and hopper barge forms. Similar experimental work on tugs and trawlers also made some progress. With regard to propulsion problems both the programme of research on propeller blade sections and the investigation into propeller scale effect were continued, while the results of tests on constant velocity sections in the compressed air tunnel at the N.P.L. formed the subject of a report to the members. Among the programmes put in hand during the year was a series of self-propulsion experiments designed to determine the results of different stern arrangements in a single screw ship.

That part of the work of the Association concerned with structures is planned to augment existing data relating to the strength and structural efficiency of ships' hulls and component parts. Measurement of relative strengths is taken and the properties of materials examined and representatives of the Association are members of the "Admiralty Advisory Committee on Structural Steel." The question of the interaction between a long deck house and the main hull of a ship, together with the problem of the expansion joint, were the subject of continued investigation. Sufficient progress was made and useful results obtained and a report issued which dealt with the influence of the width of superstructures, while the behaviour of thin-walled box girders in bending formed the subject of another report. Launching problems received attention and when conditions permitted records were taken, while the results of previous work in this field were given in a paper entitled "Stress Investigation on a Tanker During Launching," presented in January by A. J. Johnson, B.Sc., and M. Meek, before the North-East Coast Institution of Engineers and Shipbuilders.

At the testing establishment at Glengarnock the programme of work has as its object the full-scale measurement of the strength of structural components and assemblies. This is a long-term and continuous programme and the results are subjected to study with a view to incorporating them in Lloyd's rules and so giving them practical interpretation. The work has for its object the improvement in structural efficiency, so that scantlings may be reduced and deadweight increased, particular attention being paid to the effect of welding in this respect. Some of the further results of the investigations at Glengarnock were presented by J. McCallum, B.Sc., before the North-East Coast Institution of Engineers and Shipbuilders in October last, and dealt with the simple beam theory as applied to stiffened panels of plating. Apart from the full-scale work at Glengarnock many of the structural investigations were carried out on models, but the readings were correlated with the behaviour of the actual ship component. Work continued with the development of automatic strain gauges with the object of producing equipment which can be operated by the ship's personnel, as and when the correct voyage conditions obtain, so that the staff of the Association need not spend an unnecessary length of time at sea.

Problems arising from developments in subjects which have a much wider field of industrial application than shipbuilding alone continued to be of interest to the Association.

However, in such instances the research is left to the appropriate organisation, which is given active support by B.S.R.A., examples of such co-operation being the fundamental research into welding questions by the British Welding Research Association and the investigation into corrosion problems by the British Iron and Steel Research Association.

That part of the programme of the Association concerned with machinery is centred upon research to improve the performance of existing designs of diesel and steam reciprocating engines and boilers. Work continued upon the natural circulation in water-tube boilers and a report was issued upon the effect of natural circulation, associated with vertical tubes, of uniform and non-uniform heat input at a steam pressure of 1500 lb per square inch. The causes of failures of built-up crankshafts has been under investigation for some time and the results were recorded in a paper, prepared by Professor A. S. T. Thompson, D.Sc., Ph.D., A. W. Scott, B.Sc., Ph.D., and C. M. Moir, B.Sc., Ph.D., entitled "Shrink Fit Investigations in Simple Rings and Full Scale Crankshaft Webs," and read before the Institution of Mechanical Engineers in April last. A fluctuating load machine was constructed and the Royal Technical College, Glasgow, continued work on a number of other machinery items. At East Kilbride the Mechanical Engineering Research Association completed some work for B.S.R.A. dealing with the factors influencing the behaviour of top end bearings in marine engines and a report was issued giving the result of the investigations. The two experimental diesel engines which were built and installed at the Barrow works of Vickers-Armstrongs, Ltd., were used during the year to proceed with an investigation into the scavenging of marine diesels and culminated in the issue of three reports : one dealt with the effects of exhaust back pressure on engine performance ; a second was concerned with further modification to the Farnboro' electric indicator to a multi-channel indicator to improve recording of low pressure ; and the third was an analysis of light spring diagrams. In the work concerned with crankcase explosions methods of detecting the development of oil mist were surveyed and formed the subject of two reports.

The Imperial College, London, was concerned with investigations into questions of heat transfer and a report was issued on the control of scale deposits in sea water evaporators. Investigations to establish the properties of the materials used in machinery construction were continued and a study made of operational stresses and strains, while the nature of failures caused by fatigue or corrosion was given consideration. In particular, a report was issued concerning the factors contributing to the failure of diesel engine pistons and cylinder covers. A study, carried out jointly with the British Cast Iron Research Association, of the life of cast iron propellers provided material for two reports, one of which dealt with the factors governing the life of such propellers and the second had as its subject the nature of pitting attack and its prevention by means of cathodic protection. A number of reports resulted from the research by the Royal Technical College, Glasgow, into the surface finish of marine engine components and in addition a paper, with the title "Investigations on Surface Finish of Steel Shafts," was read before the Institution of Engineers and Shipbuilders in Scotland by A. S. T. Thomson, A. W. Scott, W. Ferguson and G. V. Stabler.

An important part of the work of the Association is the establishment and analysis of performance data for both ship and machinery in order to check design expectations and to verify in service the results predicted from model experiments. To assist in the work a revised code of measured mile procedure was prepared by the Association and in May H. Lackenby, M.Sc., submitted to the Institution of Naval Architects, for written discussion, a paper on the presentation of ship resistance data. Part of the trials carried out during the series of "Lucy Ashton" experiments provided data which indicated the increase in resistance due to varying degrees of hull roughness. The importance of the effect of roughness upon resistance has been confirmed by subsequent tests and a technical memorandum dealing with this subject was circulated to members of the Association. With the co-operation of a shipowner it was possible to install equipment on board a vessel and during the year service performance was measured under North Atlantic weather conditions over a period covered by several round trips.

In order to amass information with the long-term object of assisting designers to eliminate vibration, or at least reduce them to a minimum, various troubles arising from this source were investigated not only to provide an immediate remedy but also to add to the existing information on the subject. Other work followed the lines of theoretical approach, followed by experimental check and the results to date appeared in two reports, circulated to members, one of which was broadly concerned with ship vibration trial data, the other dealing generally with items of local vibration.

The latest report available concerning the work of Parsons and Marine Engineering Turbine Research and Development Association indicated that a marked degree of progress was achieved and that, under the direction of Dr. T. W. F. Brown, considerable additions were made to its volume of technical data. During the period covered by the report a new general store was completed ; a test bed constructed for the high-temperature single-stage gas turbine and approval given for the construction of a workshop to house general-purpose tools, and also for a new administrative building ; while the capacity of the pump house was doubled. A large number of design inquiries were handled and resulted in several definite orders being placed, and designs were completed for the Canadian Pacific Steamship Company's new liner and for two large oil tankers for the North American Shipping and Trading Company.

An investigation was made into the failure of a reaction turbine blade and it was found possible, due to the advances made in the Association's work on vibration theory, to estimate the vibration stresses. With regard to the problems associated with the handling of turbines under standby conditions, experiments were carried out using small steam nozzles below the water surface in the condenser sump. By this means, the report recorded, it was found that a small amount of steam maintained the water close to boiling point even when there was practically no vacuum held in the condenser. Further developments took place in connection with the double casing h.p. turbine forming part of 950 deg. Fah. installations already under construction, and a quarter-size model was built for load and thermal test purposes and loads corresponding to 20g on full scale were applied successfully. Additional tests were planned to apply loads up to the point where permanent set occurs.

In the Steam Turbine Research Department the "Y100" naval frigate machinery was dismantled and the erection of the high pressure and temperature naval machinery Y.E.A.D.I. and ancillary equipment was put in hand. Trials went forward of the experimental high-temperature steam turbine (Pamela), designed for 1100 lb per square inch and 1100 deg. Fah., and with regard to the noise reduction of machinery the first test cell for the investigation of the noise and vibration of centrifugal pumps was completed. A redesigned sampling apparatus was assembled for research on non-condensable gases in steam and a semi-micro gas analysis train received. With regard to components, a rig for turbine blade research was completed and the vibration spectra of batches of blades determined before being mounted in the rig. A cupro-nickel condenser tube having a thin silicone coating was tested as a means of producing a drop-wise rather than film-wise condensation and also served to determine the life of such a coating. The testing of furnace fuel oil pumps was continued, using the Imo pump, and further tests with cold oil were planned. A hydraulic pressure test of 975 lb per square inch was applied to a length of metalflex tubing in the test rig before testing under temperature conditions.

An examination was made of a set of 16,000 h.p. corrected gears which had been run to destruction and showed that the application of a helix angle modification to the pinions had resulted in greater load-carrying capacity. A second set of A.V.G.R.A. 8500 h.p. gears in En 26/En 9 were prepared for back-to-back tests, while in another set of tests gears having a 3½ per cent nickel steel pinion and a forged carbon steel wheel rim withstood a tooth load of 1000 lb per inch face width at a pitch line speed of 250ft per second. In a second set gears prepared for testing the materials used were 4 per cent nickel-chrome molybdenum steel for the pinion and 3 per cent nickel-chrome-molybdenum steel for the wheel rim. Bearing research was continued and included an investigation of the performance of chamfered, of thin shell and of short journal bearings, and plain bearing tests using light oil. Tests with both "A" and "B" astern converters were continued and the experimental work on disc lubrication included a study of the effect of oil viscosity on pitting. Some experience was gained with a pneumatic bearing and an investigation made into the question of tooth deflection. Work proceeded upon the improvement of instruments such as the development of strain gauges to operate at high temperatures, microphones and pick-ups, vibration motors, low-frequency wave analyser circuits, hydraulic torquemeter, and an integrating torquemeter. Certain new techniques were developed and included a prototype igniter unit, surface treatments for high temperatures, and an infra-red detector.

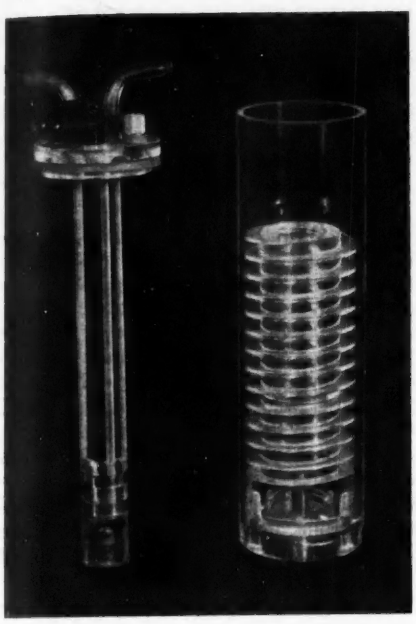
(*To be continued.*)

EUROPEAN TUNNELLING RECORD.—We are informed that the European tunnelling record has been broken. The occasion was the tunnelling on the St. Fillans section of the North of Scotland Hydro-Electric Board's Breadalbane project. The contractor, Mitchell Construction Company, was employing one "Eimco 21" Rocker-shovel on the face where the record was broken. Through very hard epidiorite rock a tunnel of 10ft. 6in diameter was cut to a distance of 428ft in seven days. Tunnelling is proceeding on all faces at the average rate of 12/1400ft per week. Actual work under cover started in August and, up to December 12th, 8500ft of various diameters had been driven on all faces ; during this period 3251ft were driven on the record breaking face. The consulting engineers for the St. Fillans works are Sir Murdoch McDonald and Partners.

Conductimetric Determination of Carbon in Metals

ONE of the lesser used methods for determining the amount of carbon in ferrous and non-ferrous metals and alloys has been the subject of recent development work by the research laboratories of The General Electric Company, Ltd., at Wembley, Middlesex. This method involves the electrical conductimetric determination of the carbon dioxide produced in the combustion of a sample of normal size (1 or 2 grammes).

Purified oxygen is supplied at a controlled rate to a " Mullite " combustion tube containing the specimen in an aluminous porcelain boat. The combustion tube temperature varies between 1100 deg. and 1300 deg. Cent., depending on the material to be analysed. A special loading device permits the boat to be pushed into the hot zone of the furnace, without admitting air, after the combustion tube has been swept out



" Perspex " conductivity cell for conductimetric determination of carbon in metals. Left, lid and central portion showing platinum electrodes and gas passages. Right, body of cell with helical gas bubble passage

with pure oxygen. The gases leaving the combustion tube are passed through granular manganese dioxide to remove oxides of sulphur and then into the " Perspex " conductivity cell (illustrated above). On the left is the lid and the central assembly, including the platinum electrodes ; on the right is the " Perspex " body and base of the cell which contains the helical passage for the gas bubbles. The cell contains a solution of caustic soda or barium hydroxide at a thermostatically controlled temperature, together with a trace of a non-ionic wetting agent.

In the cell the gas bubbles are made to follow a helical path about 55in in length, which ensures efficient absorption of the carbon dioxide. The solution circulates to the electrode chamber in the centre of the cell, where the conductivity is determined by a Wheatstone bridge circuit using a 50 c/s supply and a vibration galvanometer for null indication. An advantage of this method of determining carbon content is that the conductivity can be measured at any moment without stopping the flow of oxygen. The operator can therefore ascertain when the evolution of carbon dioxide has ceased. The measuring cell itself contains only 45 ml. of solution, which gives high sensitivity, and it is easily emptied and refilled. The conductimetric method also has the advantage of wide range, so that high-carbon cast irons can also be analysed. The work done at the G.E.C. research laboratories indicates that combustion of cast irons, iron powders, and plain carbon steels is complete and sufficiently rapid in the apparatus described, without the use of fluxing or igniting materials. With all other alloys so far analysed, either lead or tin (or both) have been found to be useful additives which do not introduce large errors. Lead is useful for iron-rich alloys and acts primarily as a flux. Tin acts mainly as an igniter and is most useful for alloys containing large amounts of nickel, cobalt or tungsten ; with high-nickel alloys tin has an additional fluxing effect.

The results shown in the following table were obtained on two standard steels and one standard cast iron from the Bureau of Analysed Samples, Ltd.:—

These determinations were made on 0·5 gramme and 1·0 gramme samples, with caustic soda solution in the cell. No result has been discarded.

Carbon in Standard Steels and Cast Iron

Carbon present according to B.A.S.		Carbon determined by conductimetric method
Average, per cent	Range, per cent	Per cent
0·029	0·0275 to 0·032	0·0289, 0·0283, 0·0283, 0·285
0·365	0·360 to 0·370	0·361, 0·363 0·363, 0·362
2·88	2·83 to 2·93	2·90, 2·89, 2·88, 2·89

On low-carbon samples containing 0·01 per cent carbon duplicate analyses agree within 0·001 per cent and usually between 0·0002 per cent or 0·0003 per cent. Sample weights have varied from 0·1 gramme to 3 grammes and close agreement has been obtained when results have been checked by independent gravimetric determinations.

Heavy Duty Mine Cars

A NUMBER of " Granby " design mine cars of particularly strong construction have been built for a Canadian mining organisation by Robert Hudson, Ltd., of Leeds. These 110 cubic feet capacity cars were required for handling high density ore, which in addition to being very abrasive is damp and contains sulphides.

The steel body plates which are $\frac{3}{8}$in thick have a tensile strength of 33/38 tons per square inch and have a 0·5 per cent copper content. The main plate is in one piece and forms the bottom and the ends with well-rounded transverse corners. As illustrated here it is reinforced by continuous channels welded on to the plate to form box sections to resist the end splaying tendency. The $\frac{5}{16}$in thick back and door plates are similarly reinforced. To cushion loading shocks, and reduce damage and wear of the main plates, a timber liner 1½in thick and a steel liner $\frac{3}{8}$in thick are secured to the body bottom. In addition ¼in thick renewable steel liner plates are

110 cubic foot capacity heavy duty mine car

provided on the door, the fixed side and the two ends. A longitudinal back corner liner is provided which with the rounded transverse corners, minimises the build-up of fines.

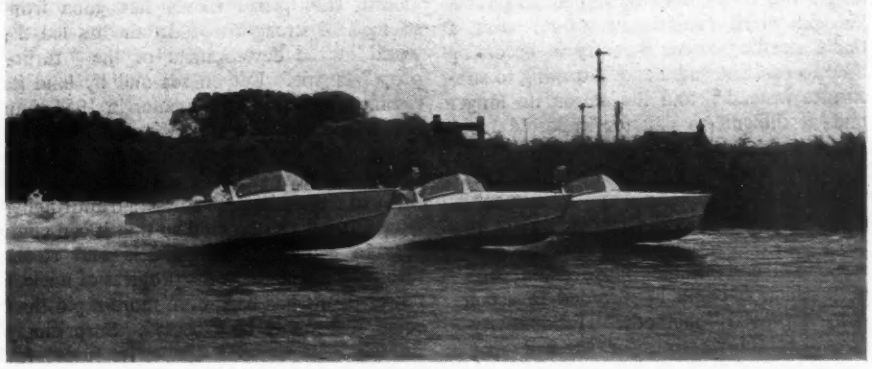
It has been found that a peening action is set up on the bottom liner plate from the constant severe blows encountered in the loading operation and to counteract this a number of bars of 5in by 1½in section are welded to that plate. Care has been taken to avoid pockets, or other obstructions to discharge, by running these bars out into the back corner liner.

The swinging door is held in the closed position by cast steel hook holders secured to the body ends. The door arms are of 1½in thick steel and the main and door pivot pins work in phosphor bronze bushes provided with grease gun lubricating nipples. The door operating linkage is adjustable.

The four cast steel body hinges have 2in diameter pins and these pins are fitted in phosphor bronze bushed top brackets provided with a grease reservoir and grease gun lubrication. A substantial steel casting which forms the main frame of the car weighs about 2000 lb and has cast steel buffers with rubber disc springs at each end. Semi-elliptical leaf springs are fitted and the four chilled cast iron wheels each have two Timken tapered roller bearings.

High-Speed Motor Boats

OUR photograph shows three high-speed pleasure motor boats on test on the River Waveney near Great Yarmouth. They have been built by Albatross Marine, Ltd., and form part of an order of 100 such craft for export to America. The boat, the " Albatross " Sports Runabout, is a 12ft 8in high-speed, three-seater motor launch which is of all-aluminium alloy construction. This highly manœuvrable craft, weighing only 560 lb, is suitable for service as a fast tender for yachts and is equipped with waterproof leather upholstery. The power unit is a Ford 10 h.p. engine, converted for marine purposes by Albatross Marine, Ltd., to give the boat a speed of 32 m.p.h.



Three high-speed motor runabouts on trial

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A RETROSPECT

How strangely Destiny works ! Or have Governments in reality more control over unfolding events than we are led to believe ? Looking back to-day over the happenings of 1954, we can see that much the same things were troubling men's minds as troubled them eight or nine years ago. Yet in writing about them we find that, as with the poems Alice had to recite, the words all "come differently." For twelve months we have watched, as we have watched in previous years, the import and export figures and the movements of the gold reserve ; we have deplored, as we have so often deplored before, the failure of coal output figures appreciably to rise ; we have listened once more to spokesmen stressing the need to increase industrial output ; and we have heard, as usual, "great argument about it and about" on education. But as compared with earlier years the emphasis has changed. For six years after the war the economy of the country had no steadiness. It swung dizzily from crisis to crisis. But in 1954 men began at last healthily to lose interest in economic figures, which only occasionally moved unfavourably and never so unfavourably as to threaten disaster. Nor does there any longer exist the same poignant longing for a year in which coal output would show a really startling rise. Industry is becoming used to coal shortages and is turning to substitutes instead ; and the nation no longer finds it difficult to pay for imported fuels. Less, too, was said in 1954 about the "vital" need to increase industrial output. The emphasis was changed. More investment in industry became the cry, providing yet one more sign that the period of making-do had come to an end and that improved "means" of production could be afforded to accompany improved "methods." Productivity—how thankful we feel, for we had grown immeasurably tired of the subject—was no longer preached nationally. As a subject for discussion it was banished to the factory floor, where it properly belongs, though its importance is still immense, since the national output can now be raised only by the improved productivity of individual workers. Even nationalisation, that beloved doctrine of the Socialists, seemed to lose its charms for many of those who had been formerly its advocates. More strongly than ever in 1954 it was revealed to be not that solvent of all industrial ills that its supporters once took it to be. For, as the New Year came in, the employees of a nationalised concern were firm in their resolve to strike for higher wages, just as though private capitalists were their employers instead of a public corporation !

Again, where, in these first few days of 1955 is the confidence once felt by the planners of the earlier Economic Surveys that manpower shortages could simply be cured by moving men from one industry to another ? "Where are the snows of yesteryear ?" There are now few important industries that are not short of labour ! Even in more technical spheres there seems, now that we can look back upon them, a dreamlike quality about some of the hopes of the immediate post-war years. Whence has the confidence of gas turbine advocates departed ? In the air, indeed, that prime mover has gone from strength to strength and Britain has led the world in the development of the "turboprop" engine. But on sea and by land its significance was barely greater in 1954 than it had been eight years earlier. Potentially eight years ago it was a promising prime mover. That is still its state to-day. That is likely to remain its state unless and until higher temperatures can be used so that it can compete in economy with diesels and steam turbines. By contrast the progress of nuclear power plants has been even more rapid than could reasonably be expected. Surprisingly enough, now, as 1955 opens, its future for land and marine use seems more assured than that of the gas turbine. Great land power plants are already under erection at Dounreay in Scotland and in America ; and in America a submarine power plant is about to go into service and a plant is projected for a large surface warship.

Much the same things were discussed in 1954 as were discussed in earlier years. But it seems to us that they were discussed by better balanced minds, no longer blinded by the curious optimism that appears to be bred by war experience. Even in an age which, we are convinced, historians will regard as one superabundant in human energy—for upon any reckoning Europe has made an astonishingly rapid recovery from its post-war exhaustion—it has come to be recognised that in the advancement of techniques progress cannot be made at more than a moderate rate in every field simultaneously. The necessary brains and knowledge just cannot be made to go round. Yet slow though advance may appear to be as the Old Year is surveyed in the first days of the New, how fast in fact we really are moving ! Mr. Butler, we think, could hardly be ranked amongst the most optimistic of men. Acting as Chancellor of the Exchequer must, indeed, be a sobering job for all who experience it. Yet in his speech before the Conservative Party Conference at Blackpool he saw "no reason why we should not double our standard of living in twenty-five years." Of course, such a statement is vague in meaning. Nor have economists who have variously interpreted it made it any the less vague. In their gloomy efforts to show how difficult it will be to achieve such a result ; or their equally depressing attempts to water the idea down to something much more modest than Mr. Butler, we think, intended, they have in fact destroyed the wonder that a responsible Chancellor should have had the courage to say anything of the kind. Of course, nobody really knows what doubling the standard of living means. Certainly it does not mean multiplying everything by two. We shall not all want to eat, twenty-five years from now, twice as much as we do to-day ; or to wear twice as many clothes ! Moreover, ought not æsthetic satisfactions to come into the account ? And would not cleaner air and purer rivers heighten living standards ? Yet in so far as the engineering and allied industries are concerned, a doubling of living standards can reasonably be taken to mean a doubling of output. Is there really anything very startling about a suggestion that output could be doubled in twenty-five years ? Judging by post-war performance we might even regard the project as a modest one but for one thing. Do the economists, we cannot help wondering, yet know enough about their subject to guarantee to the world for the next quarter of a century an economic atmosphere favourable to expansion ?

STEEL, POWER AND COAL

That there is nothing at all impossible about doubling output within twenty-five years is revealed by the post-war performances of the iron and steel and electrical industries. In 1954 the former industry produced about 18,500,000 ingot tons of steel as compared with about 12,750,000 tons in 1947. That industry has expanded

its output by nearly 50 per cent in only seven years. Figures for electric power generation reveal a similar story. Unit sales to consumers by the British Electricity Authority show an increase upon the 1947/48 performance of close upon 60 per cent in only seven years. Not all industries, of course, have achieved such rates of expansion. Notably the expansion of coal output lags. But to coal, in particular, the old economic "law of diminishing returns" applies. Increased mechanisation at the face and elsewhere in the pits barely compensates for loss of output due to the difficulties of working narrower and dirtier seams. Even the coming into use of new pits can do little more in future than compensate for the closing down of worked-out pits or those which become economically unworkable. Increasingly over the next few decades, even if the Coal Board manages to attain its relatively modest target of 250 million tons a year by 1965, coal supplies must fall short of demand. It is very probable that long before twenty-five years have passed this country will have become a net importer of coal, just as it is already, when oil is taken into account, a net importer of fuel. Nor is there anything disastrous for this country's economy implied by that comment. Increasingly in the future Britain will only be able to keep its high place amongst exporting nations by offering for sale abroad engineering and other products of designs more advanced as well as more serviceable and reliable than those produced elsewhere, that is by selling the knowledge and skill of its technologists and workers in working up imported raw materials, rather than in selling the raw materials themselves. Indeed, if shortage of coal acts as an incentive to the more rapid development in this country than elsewhere of skill in constructing, for example, nuclear power plants by the use of which coal can be economised, the shortage may prove in the longer run a positive benefit to this country rather than a handicap.

Nuclear Power

One of the more important events of 1954 was the passing of the Atomic Energy Authority Act, which set up an Authority whose concern is with the civil uses of atomic energy. One of its jobs is to encourage the education in nuclear topics of scientists and engineers. Towards the end of the year it set up a "Reactor School" at Harwell. The main objective of the School is to train men from British industrial firms to design and build economic nuclear power units as early as possible. This decision to spread knowledge of nuclear power technology more widely instead of shrouding it in secrecy has come none too soon. For, as Sir Christopher Hinton revealed in a lecture before the Institution of Mechanical Engineers in March, some very peculiar and unusual metallurgical, chemical and, above all, engineering problems have to be solved in designing and manufacturing nuclear power plants. A substantial increase in the numbers of people aware of those problems and studying alternative solutions must certainly contribute towards bringing about a more rapid advance. One of the bad effects of too much secrecy was revealed in the autumn when a project for dumping certain radioactive waste materials in disused coal-pits in the Forest of Dean encountered strong local opposition based upon groundless and ignorant fears that working in other pits in the area would become dangerous and even that tourists would shun the Forest area! That kind of ignorance should not be allowed to continue to exist. For as nuclear power plants increase in number so will the amount of radioactive waste material to be disposed of increase. There are, in fact, no insuperable, nor even any very difficult technical problems to be solved in disposing of them. But unless care is taken to educate the public, prejudices like those encountered in the Forest of Dean may be again met when, as must happen in due course, projects are formed for siting nuclear power stations in more populous areas than North-West Scotland.

Technological Training

There is a much more dangerous shortage than that of coal which might hamper the attainment of a doubled standard of living within twenty-five years. There is already within industry a sad lack of technologically trained men. The shortage has been persistent ever since the war ended ; and in 1954 it led to a continuance of that debate upon the ways of ending it that has troubled men's minds for so many years. The Socialist scheme for a Royal Technological College to give awards and approve courses at technical colleges is already dead. But little has been done to replace it. The Government's actions in 1954 did not suggest that it intends to act upon the alternative proposal that a small number of technical colleges should be elevated to the status of technological colleges providing courses of university standard but different content. Instead the Government concentrated upon expanding facilities at Imperial College, South Kensington, and at Glasgow, Manchester, Leeds, Birmingham, &c.; upon the expansion, that is, of institutions already receiving Treasury grants, thus linking development as closely as possible with existing universities. But the provision of facilities for technological education, it became more widely appreciated during the year, is only a facet of a greater problem. For during the year more places were available for students than there were students to fill them. It became, in fact, obvious that there was as much need to attract adolescents to take up technology as a career as to provide a sufficient number of courses. In consequence attention was attracted to the schools. Were the schools, it was asked, teaching science satisfactorily ? Were schoolmasters making it clear enough to boys how attractive a technological career in industry could be ? Were schoolmasters themselves sufficiently informed about technological careers ? There seemed to be grounds for doubt. For there is much evidence of a shortage of properly qualified teachers of science in the schools and not a little that the attitude of many teachers towards technology is that it is not a career suitable for the more brilliant pupils. Unfortunately, within industry, too, the value of those technologically trained is not everywhere realised. One of the more significant conclusions drawn from a survey of "Industry and Science," published in book form during the year by the University of Manchester, was that it was those firms with trained technologists on their boards which showed the greater interest in research and development and the employment of trained personnel. Many firms showed effectively no interest whatever ! Again experience reveals that many firms, even amongst the more progressive, are unwilling to release even junior executives to undertake valuable post-graduate courses like, for example, that provided by the School of Thermodynamics and Related Studies at Birmingham University. How strange it is that industry should prove backward in this way when over the last very many years the fighting services have appreciated so strongly the value of seconding men to training courses of considerable length at intervals throughout their careers the better to fit them for more responsible duties !

Road and Rail

If production is to be doubled within twenty-five years the implications for transport are obvious enough. Already British roads are far from adequate to bear the traffic they carry. Great schemes for building new roads and improving old ones will have to be carried out and methods of relieving congestion in large cities will have to be found, expensive though they may prove to be. On road policy 1954 proved to be a year of encouragement. For at long last the Government relented from the unyielding and, indeed, ridiculous attitude that the country could not afford to spend on its roads even enough properly to maintain them. In reality it cannot afford not to spend the money ! Late in the year in the Queen's Speech at the opening of a new session of Parliament and in the following debate it was revealed that the Government intended to spend "as much as two or three times the amount" allowed by the inadequate programme then existing. The maximum figure that can be thus expected works out at £45,000,000 a year, little enough in relation to the needs but, for all that, a welcome improvement. But, if the future of the roads could be seen to be rosier the situation of the railways seemed nowhere near as happy. There, too, much capital needs to be expended if economic operation is to be achieved. But how, in the many years that must elapse before modernisation can approach completion and bring its rewards, are the railways to pay their way ? That, basically, was the question being posed at the end of the year as railwaymen threatened to come out on strike for higher wages which the British Transport Commission feels it economically impossible to pay them.

Air Pollution

A higher living standard is not obtained solely by having more material things to buy. Other things contribute to it ; clean air, for example. In 1954 the whole subject of air pollution was examined by the Beaver Committee. Its conclusions fall, in reality, under two heads. If the people of this country are really determined upon it the smoke nuisance can be eliminated and it can be eliminated at a cost astonishingly

cheap in relation to the benefits to be gained. Industrially the elimination of smoke amounts largely to a matter of insisting upon more efficient fuel burning and the replacement of out-of-date appliances by modern ones. Since the benefit of smokeless air would be felt by the whole community the committee considered that firms should be offered a financial inducement by the Government to bring about improvement. Domestically the change could prove more difficult. First, people have to be induced to abandon their liking for raw coal fires ; secondly, smokeless fuel has to be made more easily purchaseable ; and, unfortunately, it is not easy to share the confidence of the committee that sufficient coke, the smokeless fuel suggested as a substitute for raw coal, could be made available. Even if a little optimistically, it is, however, possible to envisage under the terms of the committee's report that air pollution by smoke could slowly be eradicated in the years to come. But pollution by sulphur dioxide is quite another matter ! The removal of sulphur from the coal itself approaches the impossible. But flue-gas washing is so costly a process at present as to be out of the question for all but the heaviest fuel using plants like power stations. Moreover, the economic justification for it hangs in doubt. What is needed is the development of a process through the use of which the sulphur in the gases would be recovered in a form saleable to industry. Such processes are being developed. If they could produce sulphur at an economic cost a significant contribution might be made towards meeting the increasing industrial demand for sulphur, whilst at the same time ridding the air of a particularly damaging pollutant.

Flood Protection

Long before the war a proposal attracted much support that a barrage should be built across the Thames at Woolwich to hold the water upstream at a level about equal to that of an ordinary high tide. That proposal was made primarily on the grounds of amenity in Central London. But other advantages were counted upon, notably that traffic upon the river would be able to move up and downstream at all hours of the day unimpeded by the tide and that polluted water from the estuary would never be carried up into London on an incoming tide. The scheme was strongly opposed by the Port of London Authority, which feared, amongst other disadvantages, interference to the movements of shipping, and when the Services expressed fears that the necessary locks might easily be destroyed by bombing further discussion of the project came to an end. During 1954, however, the Waverley Committee, in the course of examining flood protection methods for Britain's eastern coasts, considered a suggestion for a surge-reducing barrage in the Thames, the object of which would be to lower the top water levels at London Bridge when a North Sea surge coincided with a high spring tide. The barrage was conceived as a means of avoiding immense expenditure if London is to be protected against any chance of flooding. In a paper read and discussed at a meeting of the Institution of Civil Engineers in October, the proposal was further elucidated and some of the results obtained by experiment with a hydraulic model of the estuary were given. They showed how effective the barrage could be if it were operated to stop flow in the river at some given time before high water. The Water Pollution Research Board's report for 1953, published in April, also contained information relevant in this context. That Research Laboratory is conducting a survey of the conditions in the estuary with the eventual object of facilitating decisions about policy for its future. One of its preliminary findings was revealed to be that 10 miles below London Bridge the water is so heavily polluted that at all seasons of the year, during part of each tide, there is no dissolved oxygen in the water whatever, and another that even so high up as London Bridge, right in the centre of the City of London, something very closely approaching a similarly deplorable state can be reached at certain states of the tide when the flow of the Thames is low. It is true that extensions now being made to the sewage works above the Northern Outfall and similar extensions projected for the works on the South Bank may lead to improvement. But undoubtedly a barrage above the sewage outfalls permanently maintaining a high water level upstream and designed also to protect London from the effects of North Sea surges could improve the condition of the water within the City bounds. In short, the Waverley Committee's suggestion seemed to reopen for consideration the older Woolwich barrage project.

The " Comet "

A tragedy marred 1954. Far in advance of any other company, the de Havilland concern developed its jet-propelled " Comet " airliners, and the British Overseas Airways Corporation successfully introduced them into service. Disaster followed. In May, 1953, a " Comet " aircraft disintegrated after taking off from Calcutta. The accident was blamed upon stress of weather. But in January, 1954, there was a similar unexplained failure soon after an aircraft, taking off from Rome, had reached its cruising altitude. Modifications were then made, but the cause of the accident remained incompletely explained. Then, in April, 1954, still another " Comet " fell out of the skies into the Mediterranean Sea. Every existing " Comet " was at once grounded and none has since flown in service. As the consequence of a very remarkable salvage effort nearly all parts of the wrecked " Comet " were recovered. The report of the Committee of Inquiry held during last year has not yet been published, so that it is too soon to draw firm conclusions about causes. What can be said, however, is that no aircraft structure has ever before been subjected to such comprehensive tests as those carried out by the R.A.E. at Farnborough on other " Comet " aircraft. The de Havilland company has paid that penalty that—alas !—Fate sometimes exacts to curb the temerity of those who lead advances. Engineers have to extrapolate from known experiences to the unknown. Sometimes the hazards prove too high. The future of " Comet " aircraft remains uncertain. All that can be said is that many another type of aircraft, after experiencing disasters, has lived down later its earlier unenviable reputation.

The Sword of Damocles

Damocles, according to legend, was set down to a sumptuous banquet whilst over his head there was a sword suspended by a single hair. His state matches that of our twentieth century civilisation. For over the future, suspended like the sword of Damocles by a fine thread of a continued desire for peace in the minds of the masters of Russia and of the peoples of the Western democracies there hangs—the hydrogen bomb ! Let but the dogs of world war be unleashed again and civilisation as we know it to-day might end. Life itself might become extinct on this planet. It has been estimated that as few as ten hydrogen weapons could destroy Britain's industrial capacity and as many more end that of France, Holland and Belgium.

But while Damocles, prostrate with fear, was unable to enjoy his feast, paradoxically the peoples of the world to-day are awakening to an excitement perhaps greater than has ever before shaken them in the whole history of mankind. " The poor always ye have with you." So say the scriptures. Even under the stimulation of Victorian " self help " and the Industrial Revolution there was never an expectation that the scriptures might need reinterpretation. Hard work might raise an individual from penury to wealth. It could not raise everyone to wealth. For the rest,

> " O let us love our occupations,
> Bless the squire and his relations.
> Live upon our daily rations,
> And always know our proper stations ! "

But already in the world to-day there are several nations in which no one is poor in the sense of that word to previous generations. Their condition can now better be described as less rich than the rest. By comparison with many of the peoples of the East they are rich indeed ! This is the wealth that the work of engineers and scientists is conferring on the world. It is a kind of wealth that can, in not so very long a time, benefit the innumerable people of the East as well as those, sooner blest, in the West Moreover, in enriching the world from the stores of their technological knowledge and using their industrial capacity to raise standards of living in undeveloped countries, industrialised countries stand also to enrich themselves. Indeed, unless this country contributes a share to the enrichment of backward peoples it cannot hope to acquire that doubled standard of living Mr. Butler hopes for its people. Not wholly strangely humanitarian motives go hand-in-hand with profit ! And even the development of the very weapon that now threatens to destroy the world has revealed also a source of power so potentially large as to promise plenty for the purposes of all mankind. The choice is crystal clear before us. On the one hand destruction and death ; on the other a flowering of material wealth for all, far beyond the dreams of any who have lived before.

Literature

Heat-Resisting Steels and Alloys. By C. G. CONWAY. London : George Newnes, Ltd., Tower House, Southampton Street, W.C.2. Price 25s.

THE author is to be congratulated for producing the first data book giving the high-temperature properties of commercial steels and alloys available in the United Kingdom and the U.S.A. As a reference book it will prove invaluable to those engineers and metallurgists engaged in the development of steam and gas turbines. The book is divided into the following sections :—Carbon and Low-Alloy Steels, Bolt Steels, Valve Steels, Heat-Resisting Casting Alloys, Austenitic Steels of Standard Type, Special Heat-Resisting Steels and Alloys of Proprietary Type—Iron Base Alloys, and finally a section on Nickel-Base Alloys. In each section the data is arranged under the headings of Typical Composition, Common Uses, Advantages and Disadvantages, Creep Data in both tabular and graphical form, together with physical and mechanical properties.

The author rightly informs the reader at the beginning of every section that the creep properties of materials vary from one heat to the next and advises consultation with the manufacturer before ordering material for elevated temperature service. Designers who refer to this book would be well advised to take this advice, as the creep strength of a particular alloy may differ from the average values given to a significant degree. It is unfortunate, however, that as a large amount of creep data is given in the form of stress to produce a specified creep rate, the author has not made it clear how such data should be used. He states in the Introduction that in general creep rates have been quoted and that in most cases the figures correspond closely to those for given total creep strains in the corresponding time. He refers to the fact that the creep rates should be carefully distinguished from total creep strains in a given time, but does not make it clear that, given the creep rate at, say, 1000 hours, one cannot calculate the total strain in, say, 100,000 hours.

In the section dealing with low-alloy steels reference is made to the desirability of stress relieving after welding at a temperature of between 600–700 deg. Cent. (C. steels). It is known that a high tempering temperature will reduce the creep strength of plan C. steels and the general practice is to limit the temperature at which stress relieving is carried out to 630 deg. Cent. if maximum creep strength is required. On page 49 the author recommends the use of 1 per cent Cr.Mo. bolt steel for use up to 950 deg. Fah. At this temperature the rate of stress relaxation is too high for most joint bolt applications and the 1 per cent. Cr.Mo.V. steels are more suitable. Comparison of the stress relaxation curves in Figs. 21 and 22 clearly illustrate the need for a steel superior to the 1 per cent. Cr.Mo. type at the higher temperatures.

Letter to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

SPARE PARTS AND CONVERTIBILITY

SIR,—I was pleased to read, in your issue of December 17th, the article entitled "Spare Parts and Convertibility."

Whilst working overseas before the war as manager of technical and spare parts service for an agent of a British and an American firms, I experienced the same discouraging attitude, so well described by your contributor. Whereas the appointed American representative came regularly to check our activity, insisting on us selling the whole variety of their products and not concentrating on one type of their machines, demanding that an adequate stock of spares be kept and maintained at our depot, and that service commitments be met promptly and prices to consumers not be excessive, &c., the British firm seemed more anxious to find excuses for delivery delays than to check on the agent's activity and service to customers. The inevitable result was a tendency, in the agency for which I worked, to concentrate on selling one type of equipment manufactured by the British firm and to favour the American firm whenever either British or American product could have been used.

I would like to add an aspect not covered by your contributor, but very important overseas—the seeming reluctance of British firms to send instruction booklets and spare part catalogues in any but the English language.

When, upon demobilisation, I started working in this country, I was anxious to use my knowledge and past experience for the advantage of the British export drive. Unfortunately, several years of my endeavours have resulted for me in bitter disappointment. What a relief it is to note that at last the importance of after-sales service in the export drive begins to be generally recognised. G. GAGARIN

Kings Langley, December 31, 1954.

New Year Honours

THE New Year Honours List was published on Saturday last. It includes the following awards to engineers, scientists and others engaged in the engineering and allied industries :

Barons : Dr. E. D. Adrian, O.M., president of the Royal Society and of the British Association for the Advancement of Science ; Sir William Fraser, C.B.E., chairman of the British Petroleum Company, Ltd. ; Sir Arnold Gridley, K.B.E., M.P.

Knights Bachelor : Dr. I. R. Cox, managing director of Metropolitan-Vickers Electrical Company, Ltd. ; Mr. P. E. Millbourn, honorary adviser on shipping in port to the Ministry of Transport and Civil Aviation ; Mr. W. J. Neden, chief industrial commissioner, Ministry of Labour ; Mr. Leonard Sinclair, chairman and managing director of Esso Petroleum Company, Ltd. ; Rear-Admiral M. S. Slattery, C.B., chairman and managing director of Short Brothers and Harland, Ltd. ; Mr. Henry Spurrier, managing director of Leyland Motors, Ltd.

K.C.B. : Vice-Admiral (E) F. T. Mason.

C.B. : Mr. G. R. D. Hogg, Under-Secretary, Department of Scientific and Industrial Research; Mr. W. R. McGaw, Director-General of Aircraft Production, Ministry of Supply ; Rear-Admiral (E) J. G. C. Given ; Rear-Admiral (E) P. C. Taylor ; Major-General L. N. Tyler, R.E.M.E.

C.M.G. : Mr. E. W. Senior, commercial director, British Iron and Steel Federation ; Mr. T. L. Bowring, director of public works, Hong Kong ; Mr. J. F. R. Hill, member for communications, works and development planning, Tanganyika.

K.B.E. : Sir Wilfrid Garrett, chairman of the Industrial Injuries Advisory Council ; Mr. O. H. Wansbrough-Jones, chief scientist, Ministry of Supply.

C.B.E. : Brigadier G. E. Butler, R.E.M.E.; Brigadier L. F. de V. Carey, late R.E. ; Colonel E. P. Dickson, R.E. ; Colonel H. Grattan, R.E. ; Brigadier K. Mackay, late R.E. ; Mr. C. S. Bryant, lately Director of Materials and Explosives Research and Development, Ministry of Supply ; Mr. Lewis Chapman, director of William Jessop and Sons, Ltd. ; Mr. F. W. Hallwell, president of the Gauge and Tool Makers' Association ; Mr. H. W. Hobbs, director of Ordnance Factories, Ministry of Supply, Mottingham ; Mr. F. J. C. Honey, secretary of the British Employers Confederation ; Mr. H. E. Jackson, lately president of the British Non-Ferrous Metals Federation ; Mr. N. C. Macnamara, chairman and managing director of Trollope and Colls, Ltd. ; Mr. C. T. Melling, chairman of the Eastern Electricity Board ; Mr. G. Ormston, superintendent engineer, New Zealand Shipping Company, Ltd. ; Mr. A. H. Parker, assistant director of dockyards, Admiralty; Mr. V. A. Patterson, deputy chairman and managing director of J. and E. Hall, Ltd. ; Mr. C. H. Smith, professor of instrument technology, Royal Military College of Science ; Mr. A. Watson, chief mechanical and electrical engineer, Air Ministry ; Mr. G. S. Wells, deputy chief engineer, Ministry of Housing and Local Government ; Mr. F. S. Anderson, for services to mining engineering in Australia ; Mr. E. H. R. Green, chief engineer, Post and Telecommunications Department, New Zealand ; Mr. W. S. Hall, superintending engineer, Lower Sind Barrage ; Mr. J. Beaumont, commandant, Technical Training College, Indian Air Force ; Mr. M. J. Condon, managing director of Burma Oil Company ; Mr. P. McNee, director, Drainage and Irrigation Department, Malaya.

National Coal Board Inventions Scheme

THE National Coal Board has stated that awards to the value of more than £3000 have been made to six of its employees on the recommendation of the coal industry's National Awards Tribunal, which assesses the value of original inventions in the technical field. The Board's awards scheme was set up with the object of encouraging its employees to bring forward inventions having a useful application within the Board's coal mining and ancillary activities. Local panels with the power to award up to £100 were set up in the various divisions to deal with minor inventions, and a National Tribunal (composed of three representatives of the coal industry, an engineer, a professor of chemical engineering and an independent chairman), which may recommend the award of any sum according to the merit of the invention. The Board has undertaken to accept the Tribunal's recommendations. The scheme has now been operating for nearly three years, and during this time more than 200 payments totalling about £6000 have been made by the divisional panels. Some thirty inventions coming before the National Tribunal have been awarded sums amounting in all to £17,500. Inventors appearing before the tribunal and panels have come from every level of the industry, and the Board hopes that the scheme will become increasingly valuable as time goes on. Ideas can be brought forward at an early stage so that they may be developed speedily and made available throughout the industry. This, the Board says, is an important point about the scheme, and men with ideas which they could not develop themselves have been ready to submit them to be developed by the Board's resources.

Books Received

Lathe and Shaping Machine Tools. Second edition. By Duplex. London : Percival Marshall and Co., Ltd., 23, Great Queen Street, W.C.2. Price 3s. 6d.

Fire Protection Year Book, 1955. 15th edition. Compiled by G. F. D. Pratt. London : Benn Brothers, Ltd., Bouverie House, Fleet Street, E.C.4. Price 12s. 6d.

Control-System Dynamics. By Walter R. Evans. London : McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, E.C.4. Price 7 dollars.

Uniforms and Industrial Clothing Catalogue, 1954. Edited by K. Clark. London : United Trade Press, Ltd., Boswell House, 9, Gough Square, Fleet Street, E.C.4. Price 10s.

Naval Architects' and Shipbuilders' Pocket Book. Fifteenth edition. Revised by Lloyd Woollard. London : The Technical Press, Ltd., 1, Justice Walk, Lawrence Street, S.W.3. Price 55s.

The Value of Good Design : A Report on the Scottish Design Congress, Edinburgh, 1954. Edited by Alister Maynard. Scotland : The Council of Industrial Design Scottish Committee, 95, Bothwell Street, Glasgow, C.2. Price 2s.

Electrical Engineering in 1954

No. I

FOR more than a decade the main concern of the electricity supply industry in Great Britain has been with ways and means of overcoming the serious shortage of generating plant capacity. Long before the end of the war the repercussions of this plant shortage on the peace-time economy were fully appreciated. But because of war-time priorities, and the scarcity of materials and labour in the immediate post-war years, the amount of generating plant that could be built and installed was far short of what was needed to supply the demands of industrial, commercial and domestic consumers of electricity.

This country was, therefore, faced with the prospect of some years of power rationing at a time when power was urgently needed in the task of rebuilding her peace-time economy as rapidly as possible. Voluntary load spreading, reductions in frequency and, as a last resort, power cuts, were the order of the day. Within ten years, however, thanks to the combined efforts of the electrical manufacturers and the British Electricity Authority, the rate of installation of generating plant, and of reinforcements to the grid system, had been substantially increased. The annual rate of commissioning of new plant rose from 340MW in 1947 to 566MW in 1948, 703MW in 1949, 965MW in 1950 and 1113MW in 1951. By 1952 the full output from the works extensions of many electrical manufacturers was reaching the power station sites and the generating plant commissioned in that year reached a peak of 1539MW. Since then the annual rate has declined slightly : 1413MW of new plant was installed in 1953 and 1,431MW in 1954 (as tabulated on page 26). Examples of newly installed plant are illustrated in the accompanying illustrations and those on Plate 6 facing page 29.

One of the new power stations (not illustrated here) is the semi-outdoor station at Ince, Cheshire. It is of particular interest because it is the first publicly owned power station in this country to incorporate semi-outdoor boilers. As described in an I.E.E. paper abstracted in our issue of December 18, 1953, p. 806, the main portions of the boilers will stand in the open and only the operating areas around the combustion chambers and steam drums will be enclosed, to give full weather protection to the operating staff. The semi-outdoor construction offers savings in steelwork and building costs generally. Other advantages are that boiler house staff working at or above drum level will not be subjected to excessively high temperatures ; during the annual overhaul period of any boiler it will be fully isolated from the steaming boiler units.

Ultimately, Ince power station will have an installed capacity of 240MW, generated by four 60MW hydrogen-cooled G.E.C. turbo-alternators, taking steam at 900 lb per square inch and 900 deg. Fah. from four semi-outdoor International Combustion boilers, each having an evaporative capacity of 550,000 lb per hour. Of the four sets the first was commissioned last year, the next two are due to be commissioned this year and the fourth in 1957. Four reinforced concrete cooling towers will be built to handle the requirements of the complete station. Coal for the station is railborne and the consumption is expected to reach a total of 2300 tons per day. Dust is collected from the chimneys by mechanical collectors and electrostatic precipitators and is conveyed to storage bunkers for disposal by road.

Another new station, Acton " B " (London) is intended to replace, in stages, the existing " A " station which was first started up in 1899 and now has an installed plant capacity of 158MW, some of which is over thirty years old. The new station occupies a 13 acre site consisting mainly of land south of the canal, formerly used as a sports ground and coal store for the old station. When the changeover is complete the new coal store will be on the site of the old station, including the existing wooden cooling towers. Rail access to the site is by a new bridge over the canal from the existing sidings north of the canal.

A point of interest about this station is that, to expedite building and economise in the use of steel, precast reinforced concrete was used, instead of structural steelwork, for the framework of the turbine house, transformer bays, workshops and offices. It is estimated that, in the first half of the new station building, only 330 tons of steel were used instead of the 1100 tons which would have been required for normal structural methods.

The ultimate installed capacity of the station will be 180MW, consisting of six 30MW Richardsons-Westgarth turbo-alternators, taking steam at 600 lb per square inch and 850 deg. Fah. from nine stoker-fired Mitchell Engineering boilers, each with a maximum continuous rating of 240,000 lb per hour. For the complete station condensing water to maintain an exhaust vacuum of 28·5in Hg will be cooled in three new 2,250,000 gallon per hour cooling towers and one of the existing 1,500,000 gallon per hour towers at the " A " station. To reduce carry-over these towers will be fitted with moisture eliminators.

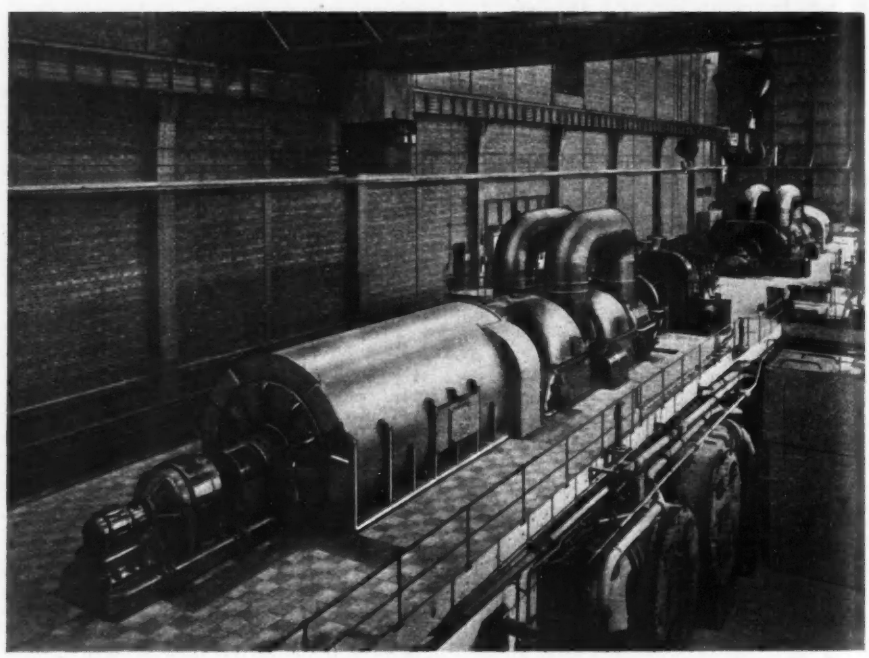
The first turbo-alternator set (Plate 6) was commissioned last year, the second set is due to be commissioned in 1955, the third in 1957 and the fourth and fifth in 1958. Acton Lane " B " is intended for operation as a two-shift station and its thermal efficiency is expected to be about 25·5 per cent.

Some Developments in Generating Plant

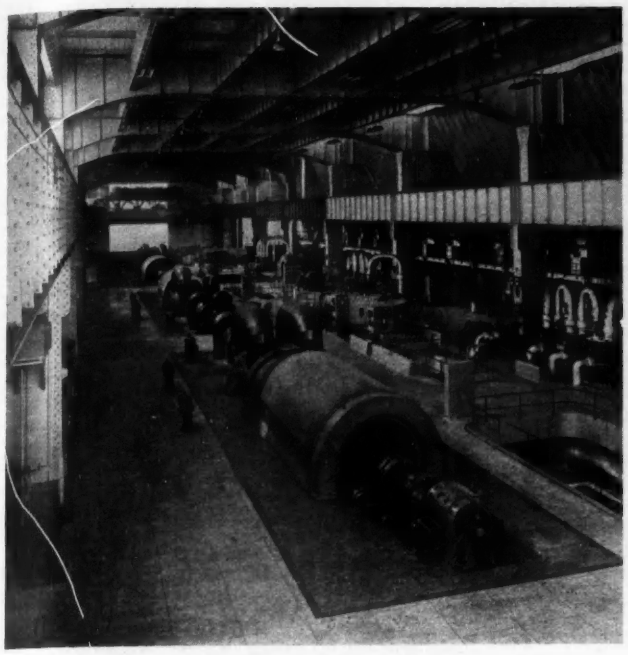
In all, the total output capacity of the British Electricity Authority's system has increased by 50 per cent since vesting day, April 1, 1948. That this achievement has gone part of the way towards restoring a balance between the available plant and the load can be gauged roughly by the progressive reduction in power cuts ; in the winter months of 1953–54 supplies were cut on only one occasion, compared with nine cuts in 1952–53 and seventy-nine in 1951–52. Too much should not, however, be inferred from these figures, depending as they do, to a great extent, on weather conditions.

For example, last winter the estimated shortage of generating capacity reached a maximum on February 2, 1954, when the estimated amount of load reduction (due to low frequency, reduction of voltage or disconnection of supply) was 879MW. According to the British Electricity Authority's sixth annual report, it was estimated that, if the weather had been extremely cold in the middle of December, 1953, there would have been a shortage of about 2200MW (sent out), compared with the corresponding estimate for mid-December, 1952, of 2400MW. It is clear, therefore, that the available generating capacity leaves no margin for very cold weather conditions, except by load shedding whenever the potential demand cannot be met.

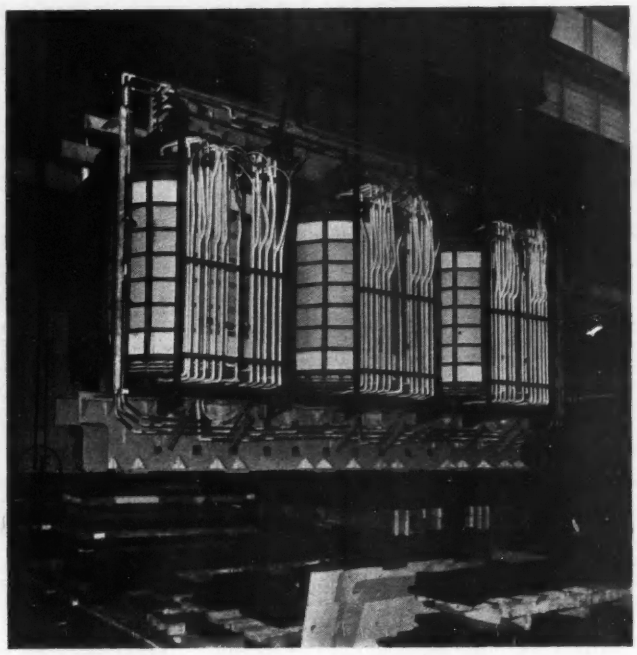
Nevertheless, the progress that has been made towards reducing the plant deficiency gives the Authority more scope to apply recent technical developments and to benefit from the drop in generation costs which can be obtained by using larger machines with higher efficiencies, as has been done in the U.S.A. on an increasing scale for a



Two 60MW hydrogen-cooled turbo-alternators installed at the Carrington (Manchester) power station of the British Electricity Authority



Three 60MW turbo-alternators in the Littlebrook "C" power station of the British Electricity Authority



120MVA three-phase, 275/132kV auto-transformer during manufacture for the British Electricity Authority

number of years. Hitherto the British electrical industry has concentrated mainly on "standard" 30MW and 60MW sets of established design, with the object of producing the maximum gross output in the shortest time. In the earlier post-war programmes, 30MW and 60MW sets predominated. In the 1959 programme, on the other hand, sets of 60MW output or less will account for a total capacity of only 680MW, while the remaining 1200MW will be made up of four 100MW sets, five 120MW sets and one 200MW set.

The 200MW set, the first of its size in this country, will be installed with a single boiler in a new power station which is projected for a site near the village of High Marnham, east of Tuxford, on the River Trent. This station forms part of a plan for using the increasing output of low quality coals from the East Midlands coalfield. The steam conditions at the turbine stop valve will be 2350 lb per square inch at 1050 deg. Fah., with reheat to 1000 deg. Fah. Ultimately, the station will contain five such turbines, each supplied by unit boilers. With its total capacity of 1000MW this station will be outstandingly the largest and most efficient yet projected in Great Britain. When it is in full operation it will consume nearly 3,000,000 tons of low-grade coal per year.

By comparison with the efficiencies that will be achieved by advanced stations such as this, the efficiencies of British steam stations to-day are modest indeed, although the annual improvement is a welcome sign. The overall thermal efficiency of B.E.A. power stations has risen steadily from 20·87 per cent in 1947–48 to 23·40 per cent in 1953–54. The three stations with the highest thermal efficiencies in 1953–54 were Portobello "B" (30·93 per cent), Stourport "B" (30·53 per cent), and Dunston "B" (30·21 per cent). On the basis of the figures quoted above, stations like Portobello "B" are more than fifteen years ahead of the average B.E.A. station, from the point of view of thermal efficiency. One of the penalties that has had to be endured because of the enforced retention of time-expired plant has been that overall thermal efficiency of the B.E.A. steam power stations is considerably lower than it would have been if the older plant had been replaced by more modern and efficient plant. The improvement in efficiency between 1947–48 and 1953–54 represents a saving of 12,000,000 tons of coal.

One of the 120MW machines referred to in a previous paragraph is being built by Metropolitan-Vickers Electrical Company, Ltd., for installation in the new Blyth power station of the North Eastern division of the British Electricity Authority. It will be a reheat machine designed for initial steam conditions of 1500 lb per square inch and 1000 deg. Fah., with reheat to 1000 deg. Fah. It will have close-coupled shafts and will be of three-cylinder construction, to facilitate reheating of the steam between the h.p. and i.p. cylinders. To minimise differential axial expansion between the turbine stator and rotor there will be a single thrust bearing, located between the high-temperature ends of the h.p. and i.p. shafts. The alternator will be cooled by hydrogen at 15 lb per square inch. Some idea of the progress embodied in this design is given by the fact that the turbine will occupy little more space than would a three-cylinder, 60MW machine of immediate post-war British design.

Some details of projected designs of 120MW and 200MW single-line tandem turbines have been given by The General Electric Company, Ltd. The new designs are developed for a reheat cycle with the following conditions:—120MW output, 1500 lb per square inch gauge, 1000 deg. Fah. reheating to 1000 deg. Fah.; 200MW output, 2350 lb per square inch gauge, 1050 deg. Fah. reheating to 1000 deg. Fah.

In both designs the turbines are three-cylinder, 3000 r.p.m. machines, with double-flow l.p. cylinders. The steam at high pressure, and at high temperature after reheat, is passed to an inner casing. With this double-shell construction the pressure difference across the casings is reduced and the thermal gradients are eased. The use of a single thrust bearing eliminates the need for relative axial sliding at the couplings.

The under surfaces of supporting lugs on the casings are brought up level with the centre line of the turbine. Thus the centre lines of the casings and the shafts are kept coincident over the whole operating range of temperature of the casings. As the supporting lugs are free to slide on their pedestals, lateral expansion of the casings is provided for. Lateral location of the casings is maintained by vertical keys on the casing centre planes.

Blading has been developed (for both ratings) to deal with the large volume of exhaust steam in only one double-flow exhaust, which simplifies the problems of expansions and allows fixed couplings to be used throughout. All blading, apart from the velocity stages, is of vortex design in which the centrifugal forces from the whirl components of the steam flowing from nozzles to moving blades are balanced by a radial pressure gradient. This condition is achieved by designing the blading with impulse conditions at the base diameter and with a degree of reaction increasing from root to tip. The moving blades are of twisted form so as to satisfy the continuity requirements of the vortex system and at the same time the inlet angle is varied to match the direction of the approaching steam. The same system provides optimum ratio of blade speed to steam speed at all diameters and the steam leaves all stages at every diameter in a substantially axial direction.

All wheels are provided with coverbands, which, in conjunction with adequate blade stiffness and the avoidance of resonance with nozzle impulses by variation of the nozzle pitching, obviate the use of lacing wires. The coverbands also permit a simple and robust system of tip sealing to be employed and on the low-pressure stages serve to limit the extent of water erosion.

Normal governing is effected by a small high-speed centrifugal governor driven from the turbine shaft which operates the four high-pressure governing valves. These valves open simultaneously and at the same rate, the governing being by throttling with no nozzle control, ensuring symmetry of steam admission to the casings is assured.

The high-pressure emergency valves are also relay operated from the main governor and open simultaneously with the governing

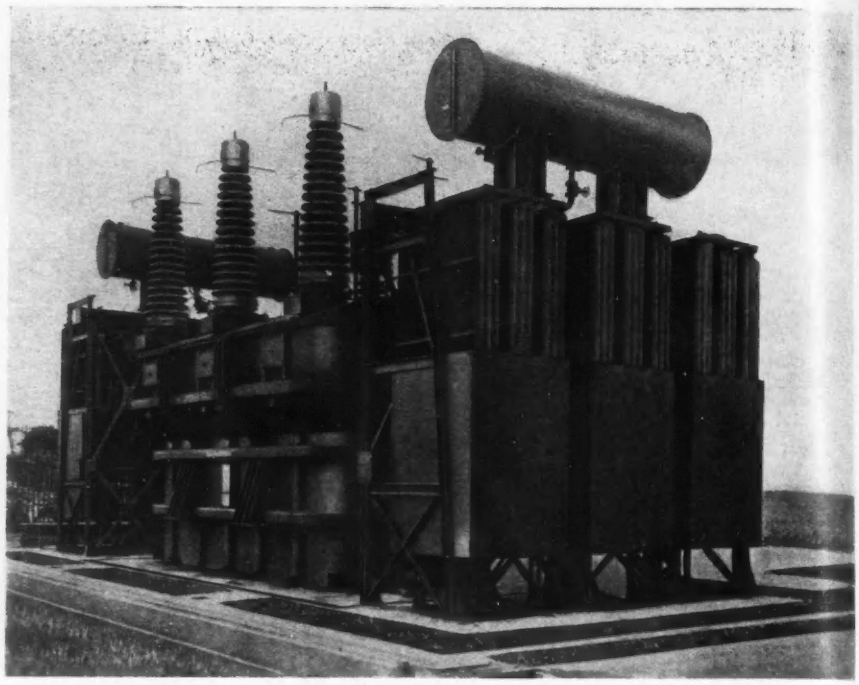
valves, but at an increased rate. Thus the steam supplied to the turbine at small loads is throttled in both emergency and governing valves, resulting in fine control and stable governing at small loads and during synchronising. At the same time the emergency valves move when small changes of load occur during normal service to ensure that their spindles remain free.

In the event of sudden loss of load, the large quantity of steam stored in the reheating section of the boiler and in the connecting piping would contain sufficient energy to produce an excessive overspeed. The interceptor valves are provided to prevent the passage of this steam through the intermediate pressure and low-pressure turbines and the dumping valves provide an alternative escape route.

The interceptor and dumping valves are operated by a centrifugal speed governor driven from the turbine shaft, acting independently of the main governor. It is set to a higher speed value than the main governor and comes into operation if the speed rises above the no-load speed of the main governor corresponding to a main governor setting of normal speed at M.C.R.

Besides the secondary speed-governor there is an acceleration-sensitive governor and, in the event of sudden complete loss of load, it closes the high-pressure emergency and governing valves, closes the interceptor valves and opens the dumping valves.

Means are provided for independent testing of the emergency overspeed governors and also for testing of the interceptor valves. Testing of the latter can be carried out on load, each interceptor valve in turn being rapidly closed and immediately reopened by relays provided for this purpose.



120MVA, 275/132kV auto-transformer installed at Carrington (Manchester) on the British Electricity Authority's super-grid

Progress in the design of supervisory equipment for turbo-alternators includes the development of an improved and more comprehensive "Turbovisory" equipment by Metropolitan-Vickers Electrical Company, Ltd. These improvements are based on operational experience with earlier versions in service in power stations. The first of the new "Turbovisory" equipments was used

Generating Plant Commissioned by British Electricity Authority in 1954

Name of power station	B.E.A. Divisions	Turbo-generator plant		Boiler plant		Main high-pressure pipework
		Installed capacity in MW	Maker	Capacity in lb/hr	Maker	Maker
Steam Plant						
*Acton Lane "B"	London	1×30	Richardsons, Westgarth	2×240,000	Mitchell	Aiton
Barking "C"	London	1×75	British Thomson-Houston	2×405,000	Babcock and Wilcox	Aiton
Battersea "B"	London	—	—	1×425,000	Babcock and Wilcox	Aiton
Blackburn	North West, Merseyside and North Wales	1×40	English Electric Company	2×150,000	Simon-Carves	Babcock and Wilcox
Bold "A"	North West, Merseyside and North Wales	1×30	Metropolitan-Vickers	1×300,000	Yarrow	Aiton
Braehead	South West Scotland	—	—	1×300,000	Babcock and Wilcox	Babcock and Wilcox
Brighton "B"	South Eastern	—	—	1×320,000	Babcock and Wilcox	C. A. Parsons
Brunswick Wharf	London	1×52·5	Metropolitan-Vickers	4×320,000	Clarke Chapman	C. A. Parsons
Carmarthen Bay	South Wales	1×60	Metropolitan-Vickers	2×240,000	Babcock and Wilcox	Stewarts and Lloyds
Carrington	North West, Merseyside and North Wales	1×60	Metropolitan-Vickers	1×360,000	Babcock and Wilcox	Stewarts and Lloyds
Chadderton	North West, Merseyside and North Wales	1×60	Metropolitan-Vickers	3×360,000	Simon-Carves	Stewarts and Lloyds
Cliff Quay	Eastern	—	—	1×365,000	Babcock and Wilcox	Aiton
Connah's Quay	North West, Merseyside and North Wales	1×30	C. A. Parsons	1×300,000	International Combustion	J. Thompson
Deptford East	London	1×52·5	Metropolitan-Vickers	1×250,000	Foster Wheeler	J. Thompson
Doncaster	Yorkshire	1×30	General Electric Company	1×180,000	Mitchell	Aiton
*Drakelow "A"	East Midlands/Midlands	1×60	English Electric Company	1×515,000	International Combustion	Aiton
East Yelland	South Western	1×30	C. A. Parsons	2×180,000	J. Thompson	C. A. Parsons
*Hackney "B"	London	1×30	C. A. Parsons	1×300,000	Simon-Carves	C. A. Parsons
Huddersfield	Yorkshire	—	—	1×180,000	Bennis	C. A. Parsons
*Ince	North West, Merseyside and North Wales	1×60	General Electric Company	1×550,000	International Combustion	Babcock and Wilcox
Keadby	Yorkshire	2×60	C. A. Parsons	2×550,000	Stirling Boiler Company/B. and W.	C. A. Parsons
Littlebrook "C"	South Eastern	—	—	1×360,000	International Combustion	C. A. Parsons
Nechells "B"	Midlands	—	—	2×230,000	International Combustion	Stewarts and Lloyds
Portobello	South East Scotland	1×60	Richardsons, Westgarth	1×540,000	International Combustion	Aiton
Roosecote	North West, Merseyside and North Wales	2×30	Metropolitan-Vickers	2×300,000	Yarrow	Aiton
Skelton Grange "A"	Yorkshire	2×60	C. A. Parsons	1×550,000	International Combustion	Aiton
Southport	North West, Merseyside and North Wales	—	—	1× 85,000	Yarrow	Stewarts and Lloyds
Staythorpe "A"	East Midlands	—	—	1×240,000	Babcock and Wilcox	Babcock and Wilcox
Stourport "B"	Midlands	1×60	English Electric Company	1×515,000	International Combustion	Aiton
*Stella South	North Eastern	1×60	C. A. Parsons	1×550,000	Clarke Chapman	C. A. Parsons
Thornhill	Yorkshire	1×45	English Electric Company	1×200,000	Mitchell	Stewarts and Lloyds
Uskmouth "A"	South Wales	2×60	General Electric Company	5×360,000	Babcock and Wilcox	Aiton
Wallasey	North West, Merseyside and North Wales	—	—	1× 85,000	Yarrow	Stewarts and Lloyds
Walsall	Midlands	2×30	British Thomson-Houston	—	—	Aiton
	Aggregates	1405MW		16,220,000 lb/hr		
Diesel Plant						
Alderley Edge	North West, Merseyside and North Wales	1×2	Mirrlees, Bickerton and Day			
*Ashford "B"	South Eastern	2×2	Mirrlees, Bickerton and Day			
Barugh	Yorkshire	2×2	Mirrlees, Bickerton and Day			
Blackpool	North West, Merseyside and North Wales	5×1·28	Harland and Wolff			
Buxton	North West, Merseyside and North Wales	2×2	Mirrlees, Bickerton and Day			
Clacton	Eastern	1×0·95	English Electric Company			
Haverfordwest	South Wales	2×1·22	Crossley Bros.			
Newbury	Southern	1×1·04	Ruston and Hornsby			
Southend	Eastern	1×0·95	English Electric Company			
	Aggregate	25·780MW				

* These power stations are new stations, in which plant has been commissioned for the first time in 1954.

in recent works tests on the new two-cylinder 60MW Metropolitan-Vickers turbines destined for Portishead " B " power station. This turbine, incidentally, is the first of a new series of close-coupled tandem-compound machines (the larger of which include multiple reheat). The main characteristics of the design are the saving in space obtained partly by improved mechanical design ; the use of fewer bearings ; and the replacement of large flexible rotor couplings by rigid couplings. As for the new " Turbovisory " equipment, it provides continuous recording of speed and eccentricity in the h.p. rotor and recording, at fixed intervals, of rotor relative expansion, and of generator load and selected steam and metal temperatures.

An interesting instrument that is being developed by the British Thomson-Houston Company, Ltd., in this field consists of a " clearance monitor " in the form of an electronic probe by which it is hoped to measure the actual clearances and the differential expansion inside a turbine cylinder.

A number of ideas are being incorporated in a 1750kW back-pressure turbine which is being made for installation in the B.T.H. Rugby works power house. On this machine a new speed-and-pressure governing system is being used ; it consists of a ball-and-cone governor linked with an integral pressure regulator and a new design of friction clutch synchronising gear. A simplified form of oil pressure regulator, which is sensed from the low-pressure oil system, has been designed for this set. The carbon labyrinth gland will be of a new kind, allowing finer clearances to be maintained. Another improvement is in the method of sealing the joint between the casing and the first nozzle : instead of being made, as usual by clamping screws, the joint is maintained by its own steam pressure. Throttle governing is also being used.

Improvements made by the same company in alternator design include the adoption of " direct-cooled " rotor windings. An interesting development completed during the year was the production of a fabricated stator casing which needed no machining before the final boring operation. All the parts for the casing were flame cut by electronic methods and were assembled as a fabricated unit without any machining work.

The Grid System

As stated in the British Electricity Authority's sixth annual report, the B.E.A. main transmission system (the grid), as at March 31, 1954, consisted of 5155 route-miles as tabulated below :—

Voltage	Overhead lines (route-miles)	Cables (route-miles)
275kV	41	—
132kV	4537	78
66kV or lower	133	366

It may be recalled that the first section of the 275kV super-grid, consisting of 41 miles of circuit line between Staythorpe (Newark) and West Melton (Sheffield) was put into service at the designed voltage of 275kV on July 15, 1953, together with the associated 120MVA auto-transformers at Staythorpe and West Melton. During the year under review the next stage of the super-grid (consisting of 120 miles of double-circuit line with twin 0·175 square inch conductors per phase, between West Melton and Stella, near Newcastle upon Tyne) was ready for initial operation at 132kV, pending completion of the 275kV substation at Stella, in 1955. Good progress was also made with other sections of the super-grid required for service by 1955, including the substations at Iver, Elstree, Staythorpe, Carrington, Stella, Carlisle, and Clydes Mill (Glasgow). Contracts were also placed for sections of the 275kV system required for 1956.

To prevent overloading of the 132kV Scottish grid lines (a contingency which could occur under certain circumstances during large transfers of power between England and Scotland), power-flow and voltage regulators were installed at Glenlee in the Glenlee-Tongland 132kV line. To facilitate the control of power on part of the transmission system in the North Eastern Division of the B.E.A., similar regulating equipment was installed at Potter House in the Dunston-Norton 132kV line. These regulators are designed to carry a load of 90MVA and are the largest of their kind built in this country. Reactors rated at 90MVA at 132kV were installed at Barking, Brunswick Wharf (Poplar) and Braehead (Renfrew) to cater for increases in generating capacity at those stations without over stressing existing switchgear or requiring the installation of new switchgear.

(*To be continued*)

Development of the Lost-Wax Process of Precision Casting, 1949–53*

No. I

By J. S. TURNBULL†

The author discusses the limitations of the original lost-wax process (1945–49) *and describes improved methods developed in the precision casting shop of the Metropolitan-Vickers Electrical Company, Ltd., by which the process has extended its application in industry. In the technique of wax injection, methods are described for eliminating "draw" in wax patterns and for making accurate patterns considerably larger in size. Wax injection machines are also described. In the manufacture of moulds the new Investment X technique of shell moulding is described.*

The author's first paper on the subject‡ was a general description of the lost-wax process of precision casting as practised in Britain at that time.

This present paper is concerned with the development of the process in the precision casting shop of the Metropolitan-Vickers Electrical Company, Ltd. This " lost-wax " foundry differs in many respects from other foundries. Not only has it to satisfy a demand for large quantities of gas turbine components, but also to supply, for use in the company's electrical and mechanical products, considerably larger castings of all sizes and complexities, for the production of which the original process was totally unsuited.

Investment X Process

The wax pattern assembly is first spray-coated or dip-coated in the usual manner, and is then provided with a multiplicity of superimposed dip coatings, which result in the pattern being invested with a shell of refractory materials of substantial thickness. After formation of the shell the wax is removed by immersion in trichlorethylene vapour, the mould is then completed by packing the shell in a Nimonic 75 canister with dry refractory material.

Fig. 1 shows a wax pattern being dipped in an ethyl-silicate-bonded slurry. It is important that the consistency of the slurry is maintained ; this is effected by a stirrer and a rotating dip bowl.

After dipping, the shell is showered with molochite in a stucco-rain machine (Fig. 2).

The shell is next treated in a drying tunnel, designed so that after one complete revolution of the circular table the pattern is ready for the next dip coat. It is usual to work a batch of twenty assemblies. Although the majority of patterns receive only six dip coats, when investing large patterns eight dip coats are used. The usual thickness of investment varies with pattern assembly size from $\frac{1}{4}$in to $\frac{1}{2}$in.

Fig. 3 shows a turbine blade assembly after

Fig. 1—Rotating slurry-tip bowl and stirrer designed for Investment X process

wax has been recovered. In the case of some blades the investment has been sectioned.

With Investment X the wax must be removed from the mould (Fig. 4) in a solvent vapour bath. The use of trichlorethylene vapour is ideal for this purpose. If oven treatment is used the thermal expansion of the wax will crack the shell investment. The reason for the trichlorethylene bath is that the solvent vapour will permeate the porous shell and immediately dissolve the wax faces adjoining the investment, before the heat of the solvent vapour expands the wax. A mould of 15 lb capacity can be completely de-waxed in thirty to forty-five minutes. A further advantage of this process is that substantially all the wax is removed from the mould cavities and the investment. Even if the mould cavity wax will not drain by gravitational flow into the main runner, it will be removed by solution treatment through the permeable mould wall.

Wax dissolved in trichlorethylene drains into the bottom of the tank, where the concentration of wax builds up as a function of time. Periodically the trichlorethylene wax solution is transferred from the de-waxing tank into a distillation tank of similar size and construction. The solution is heated to 120 deg. Cent. by high-pressure hot water passing through a tubular system in the bottom of the tank. The trichlorethylene driven off in the form of vapour condenses on cold water pipes coiled inside the top of the tank and is collected in guttering below the pipes, which is connected to an outlet pipe. The recovered trichlorethylene is re-used to de-wax further moulds, the wax is filtered and used again to make new wax patterns. It does not appear to matter how many times wax recovered in this manner goes through the precision casting process.

In some instances, particularly in the case of non-ferrous castings, the moulds are fired and cast without further supporting media. When pressure casting is being carried out with a

Fig. 2—" Stucco-rain " machine for Investment X process

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* Paper presented to the Institution of Mechanical Engineers, December 31, 1954. Abridged.

† Works Development Engineer, Metropolitan-Vickers Electrical Company, Ltd., Manchester.

‡ Turbull, J. S.: 1950 *Proc. I.Mech.E.*, Vol. 162, page 66 "'Lost Wax' Process of Precision Casting."

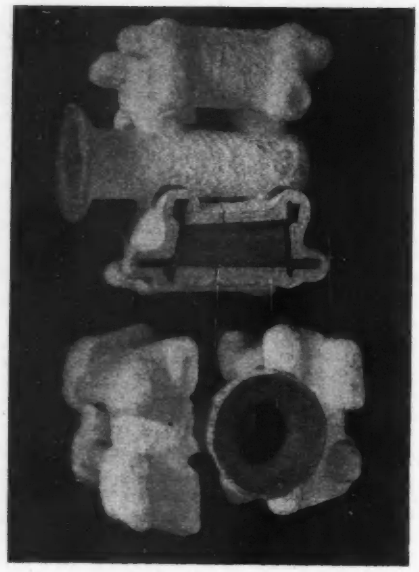


Fig. 3—Investment X shells after de-waxing in trichlorethylene bath

Fig. 4—Investment X shell moulds in trichlorethylene de-waxing bath

centrifuge the shell investments are packed in Nimonic 75 boxes, a refractory mixture consisting of sand and molochite being used.

During the baking cycle the sand frits, thereby converting a relatively "fluid" mould support into a "solid" one which will easily withstand the casting stresses. While the mould is cooling down to room temperature the sand very conveniently "unfrits," thereby changing the solid state of the mould support to a fluid. This considerably eases the problems of knocking out the mould into a matter of pouring the sand-molochite mixture into a bin. The shell investment is then separated from the casting by vibration. The casting is shotblast, cut off, &c.

Appraisal of the Investment X Process

The foremost advantage of the Investment X process as compared with the solid mould technique is its simplicity. From the point of view of shop management the following points should be emphasised :—

(1) No preparation, assembly and stripping of mould boxes, bases, and extensions is needed.

(2) No vibration is necessary.

(3) No drying oven is required so that the danger of risk of explosion is eliminated.

(4) No knocking out of moulds is necessary ; the mould can be poured out.

(5) Slurry mixing is cut to the mixing of a single-dip bowl.

(6) Handling and re-grinding of mould materials is cut by 75 per cent.

(7) Owing to the greatly reduced weights of the shell moulds, handling problems are considerably eased.

(8) On a given floor area the Investment X process will give between two and three times the production obtained by average solid-mould methods.

(9) Simplified methods of investment lead to reduced breakage.

(10) Owing to the simplification of the Investment X process over solid-mould techniques, unskilled labour can be more easily trained.

From the technical viewpoint the following advantages are apparent :—

(1) The removal of the wax by the trichlorethylene vapour gives the mould a consistent permeability.

(2) The mould has a much higher permeability.

(3) The reduced thermal capacity of the shell reduces the liability of short-run castings and enables moulds to be poured at the lowest possible temperatures.

(4) The formation of refractory solids, due to the investment liquid attacking the wax or filling the space between wax and primary coating is avoided.

(5) Mould cracking is eliminated.

(6) The dissolving of the wax pattern in the trichlorethylene bath has no ill effects on the primary coating (during de-waxing cycle on solid mould technique, the expansion of the wax can cause flaking of the primary coat).

(7) Progressive solidification can be achieved by cooling parts of the shell before the metal is cast. This can be done by coiling a heat-resistant metal tube locally around the shell mould and blowing cold air through it for several minutes before casting the metal.

(8) Owing to the substantially reduced quantities of materials used to make shell moulds, it is economically feasible to use first-class refractories, bonding materials, &c.

(9) The use of hollow wax patterns is possible by the Investment X process, whereas the solid investment process is liable to collapse the pattern.

(10) The unscientific disposition of a large number of wax patterns in a given volume as required by the economics of solid-mould technique is no longer necessary. The patterns can now be disposed symmetrically around the main runner, either for gravity or centrifugal casting.

(11) The shell mould produced by multiple dipping and stuccoing is of identical texture on all faces, whereas a solid mould which is vibrated will have a weak surface on the underside of the wax pattern owing to differences in packing of the particles.

(12) Larger castings can be made.

Solid-Mould Technique

Where a component such as a rotor has to be considered for investment, the solid mould technique is preferable, since it fills the small spaces between the blades and prevents metal penetration. If Investment X is applied the coat build-up is too thin to be effective, and there is always likely to be an air pocket between the two coatings, which may cause investment failure.

This is not only true of rotor castings but also of all instances where internal shapes do not allow the Investment X shell to be thick enough. It is not always necessary that a solid mould should be made, since compromises can often be made between the two techniques ; and it is quite practicable to invest part of a wax pattern by solid-mould technique, and to complete the mould by Investment X.

Fig. 5 shows a bren gun breech block partially invested, with the solid-mould technique used to complete complex coring. Fig. 6 shows the mould completed by the Investment X process.

The use of the Investment X method becomes more and more desirable when larger castings are being considered. The shells are much more easily handled than solid moulds, and differential expansions and contractions are not as detrimental as for solid-mould technique.

Mould Handling

The method most commonly used in lost-wax casting is as described in Turnbull (1950), whereby a mould is clamped on to the top plate of an indirect arc "top-hat" furnace and molten steel poured by rotating the furnace on its trunnions. This method has much to recommend it for small moulds with casting weights from 5 lb to 10 lb, but as the moulds increase in size and weight this process becomes more and more impracticable.

The Investment X mould is not as heavy as the normal solid mould by virtue of the decreased density of its packing material ; consequently, handling for larger moulds is simplified. These moulds do not have to be inverted and clamped on to furnace top plates ; consequently their operational movement can be done almost entirely on roller conveyors.

Where the metal is cast direct into the shell mould without its backing materials, the weight of the mould becomes only a fraction of the weight of a solid mould.

(To be continued)

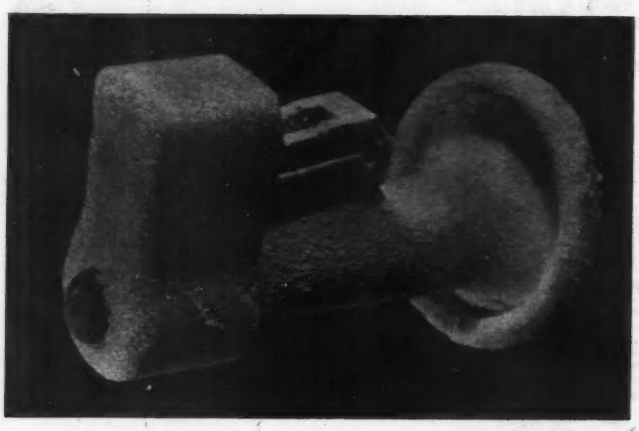


Fig. 5—Wax pattern assembly where the intricate coring on the upper half of the pattern has been effected by solid-mould technique

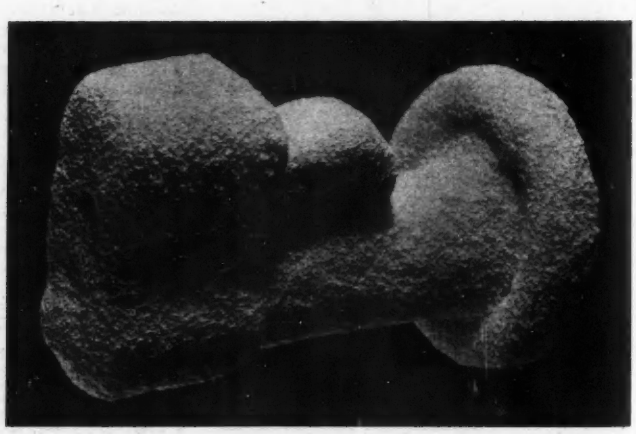
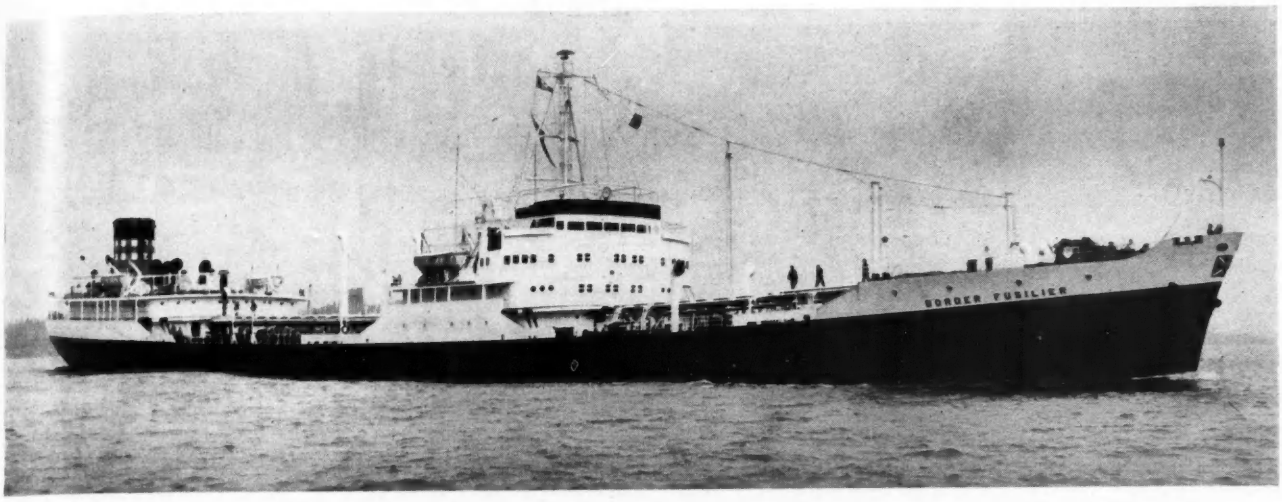
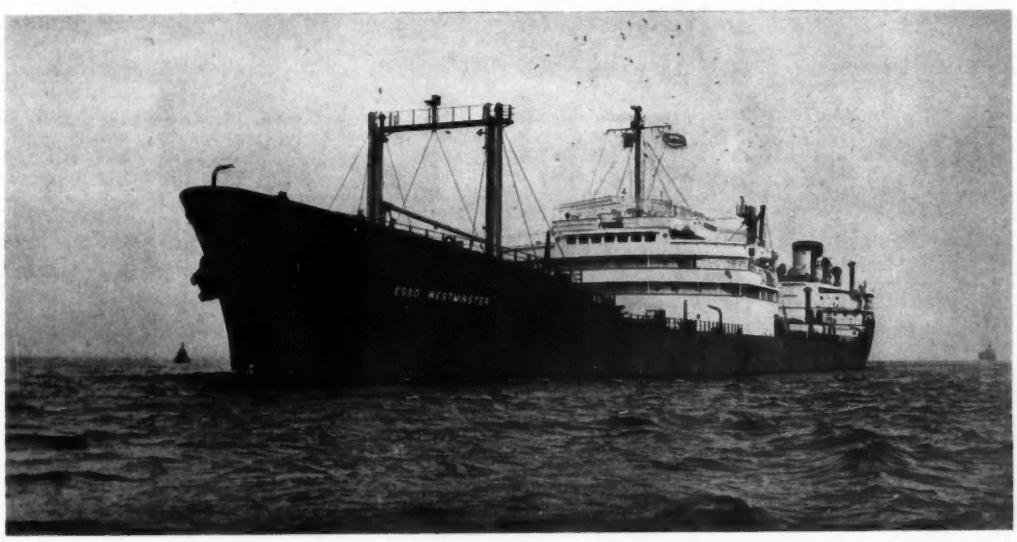


Fig. 6—Completion of mould (shown in Fig. 5) by Investment X process

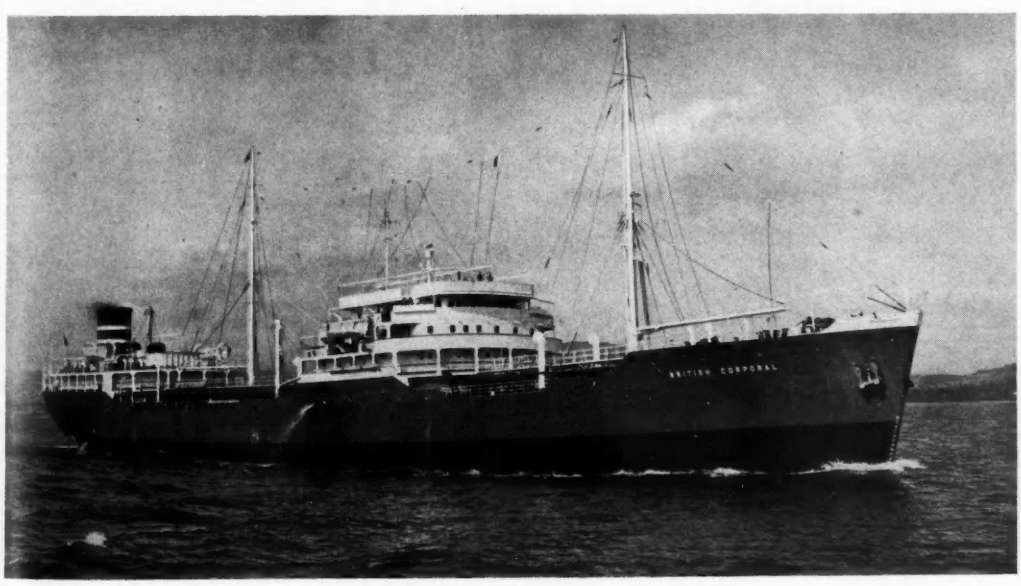
OIL TANKERS OF 1954



"Border Fusilier." The Lowland Tanker Company, Ltd., took delivery of the 16,100-ton deadweight tanker "Border Fusilier" from Hawthorn Leslie (Shipbuilders), Ltd., and the ship has an overall length of 547ft, a moulded breadth of 69ft 6in, and a moulded depth of 37ft 6in. The cargo oil is carried in twenty-seven compartments and is handled by a total of four horizontal duplex pumps in two pump rooms. For supplying steam for cargo pumping and heating there are two auxiliary boilers, while for the motor-driven auxiliaries the necessary electrical power is provided by two 150kW diesel-driven generators and one 75kW steam-driven generator. A Hawthorn-Doxford oil engine, having six cylinders of 670mm diameter by 2320mm combined stroke, and developing 6400 b.h.p. on service at 115 r.p.m., is installed

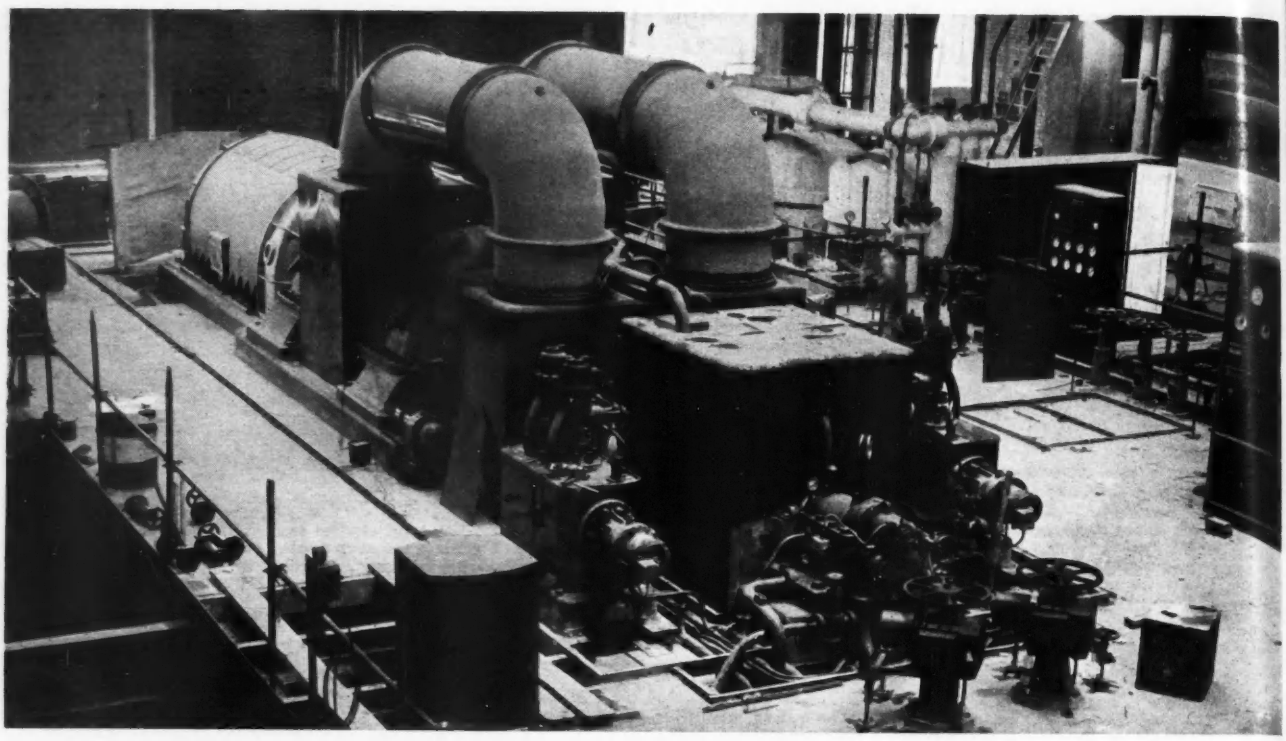


"Esso Westminster" built by Vickers-Armstrongs, Ltd., at Barrow for the Esso Petroleum Co., Ltd. The ship carries a deadweight of 26,650 tons on the following dimensions: length between perpendiculars 600ft, breadth moulded 82ft 6in, and depth moulded 42ft 6in. The ship has thirty cargo oil tanks served by four 3500 gallons per minute turbine driven cargo oil pumps and three 585 gallons per minute stripping pumps. The propelling machinery consists of a single set of Pametrada designed, double reduction geared two casing Parsons turbines which develop 12,500 s.h.p. on service at 112 r.p.m. at the propeller and take steam at 850 lb per square inch and 850 deg. Fah. from two Babcock and Wilcox integral furnace boilers

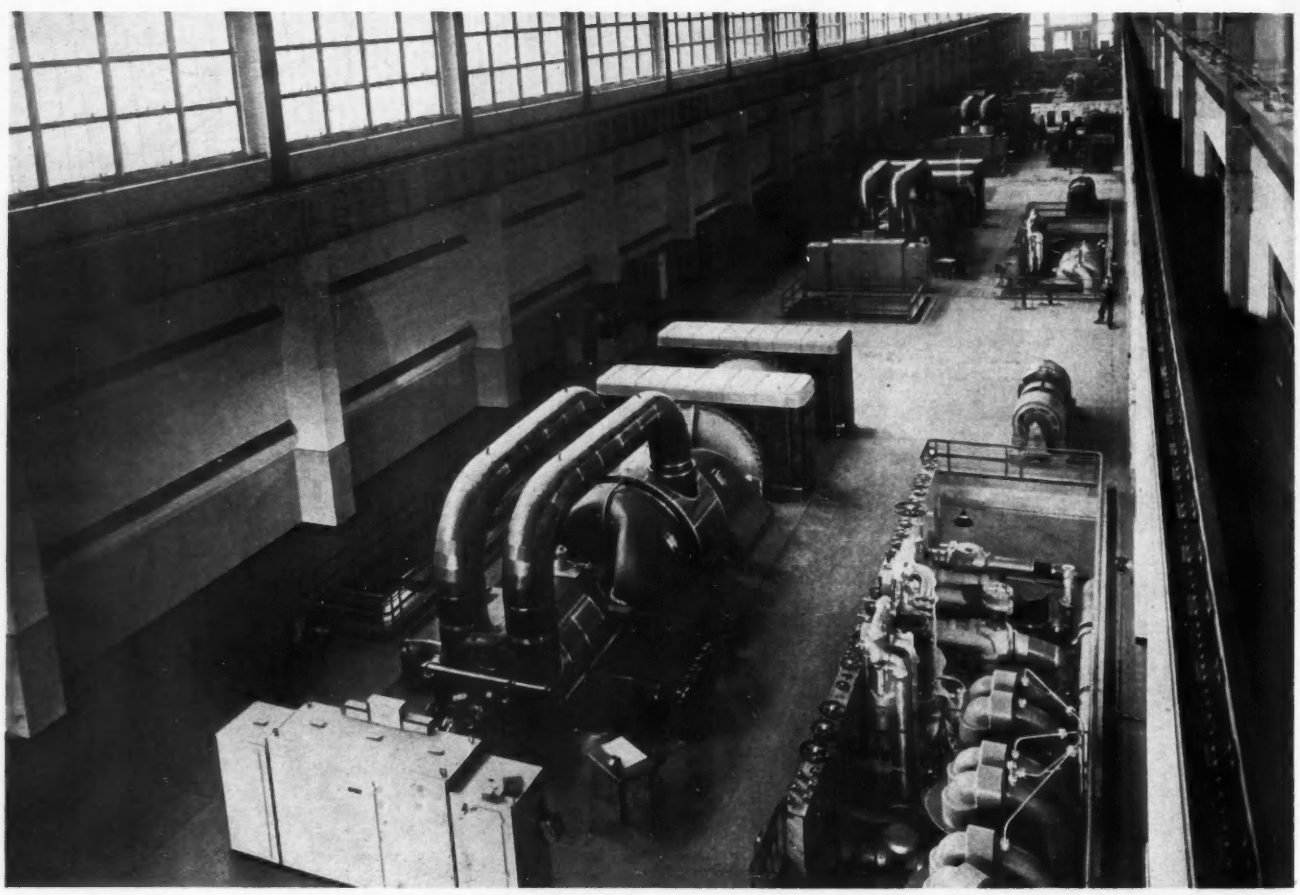


"British Corporal." This is one of the smaller oil tankers which joined the fleet of the British Tanker Company, Ltd. The ship which was built and engined by Harland and Wolff, Ltd., has the following dimensions: length overall 518ft, length between perpendiculars 490ft, breadth moulded 65ft, depth moulded 36ft; it carries a deadweight of about 14,000 tons. There are twenty-seven cargo oil tanks and two main cargo pump rooms and steam-driven deck machinery, while the electrical requirements are met by two 125kW diesel-driven generators and one 50kW steam-driven generator. Two single-ended, three furnace multi-tubular boilers provide steam at 150 lb per square inch and the ship is propelled by a Harland-B. and W., two-stroke, single-acting, opposed piston diesel engine having six cylinders of 620mm diameter by 1870mm combined stroke

POWER STATION PLANT IN 1954



The first of six 30MW turbo-alternators during installation at Acton Lane power station. The turbine house structure consists of precast concrete members, as described in our issue of February 1, 1952



60MW hydrogen-cooled turbo-alternators in the 360MW power station at Uskmouth. The station was officially opened on October 7, 1953, when two sets were in commission. Two more sets were commissioned during 1954

Naval Construction in 1954

RAYMOND V. B. BLACKMAN

No. I

Great Britain

THE highlight of naval construction in 1954 was the final completion of three "intermediate" fleet aircraft carriers, namely, the "Albion," "Bulwark" and "Centaur," which now collectively constitute the mainstay of the Fleet, since all the older aircraft carriers and all our battleships have been withdrawn from operational service and so few cruisers remain in active commission.

Aircraft Carriers

The "Centaur," which was laid down on May 30, 1944, and launched on April 22, 1947, had actually been completed to the original concept at the Belfast yard of Harland and Wolff, Ltd., towards the end of the previous year, but after trials and provisional acceptance from the builders by the Admiralty she went straight back into the melee of shipbuilding for modification to incorporate angled deck arrangements at the Royal Dockyard, Portsmouth, from which she started her final sea trials during the last week of April. But the "Albion"—see Plate 1—differed in that angled deck arrangements were built into her at the yard in which she was constructed from the keel, Swan, Hunter and Wigham Richardson, Ltd., Wallsend-on-Tyne, with main propelling machinery by the Wallsend Slipway and Engineering Company, Ltd. She was laid down on March 23, 1944, and was launched on May 6, 1947, being completed on May 26, 1954.

H.M.S. "Bulwark," laid down over a year later, on May 30, 1945, was launched on June 22, 1948, and it was officially announced by the Admiralty on November 4, 1954, that she had been provisionally accepted into Her Majesty's Service from her builders, Harland and Wolff, Ltd., of Belfast, who were also responsible for her main machinery made at their Queen's Island works, and who incorporated in her the angled deck and the latest developments in carrier operating technique, including the mirror deck landing aid. Unlike her two sister ships, which are intended for fleet operations, with squadrons of front-line aircraft, the "Bulwark," on completion of certain outstanding trials and working up, will take over the duties of the Royal Navy's trials and training carrier and she will accommodate and experiment with the various aircraft necessary for those duties, but will have no specific squadrons allocated to her.

Initially conceived in the improved light fleet aircraft carrier category, all three of the above ships are considerably enlarged vessels compared with forerunners of the type, with propelling machinery of nearly twice the power of the original light fleet carrier class, a plant designed to give an increase in speed of about 5 knots, thus obviating the inherent limitations of the inadequate 13,190-ton and 13,350-ton carriers and bringing them more into line with modern fleet aircraft carrier requirements. Improvements incorporated in them during their long period of nine to ten years under construction, however, as a result of successive recasting of design since they were first ordered, increased the originally projected nominal displacement figure from 18,300 tons to 20,180 tons standard and 25,760 tons full load, still further increased by the installation of the angled deck and ballasting in compensation of top weight.

Aircraft and flight deck equipment are parked to the starboard side of the angled deck boundary line. Each ship is equipped with six wires spaced equally along the line of the angled deck and capable of arresting any naval aircraft in Service use. Two large aircraft lifts operate between the hangar and the flight deck, and an automatic bomb hoist provides weapons of all descriptions from the magazines to the flight deck and hangar. Two hydraulic catapults are fitted in each ship, each of which is capable of launching a heavy aircraft, providing a rapid method of getting aircraft airborne without the necessity of turning the ship exactly into wind. They are ideal for operating high-performance jet aircraft whose acceleration at low altitudes is such that a high wind speed along the deck is essential for take-off.

Each ship has two shafts propelled by similar turbine units, and each main engine unit is supplied from two Admiralty three-drum boilers fitted with economisers and superheaters. Steering arrangements comprise twin rudders, which may be operated by steam, electric or diesel power units. Air conditioning is available for the more important positions manned at action stations. The ships were designed to withstand considerable damage. Underwater protection is based on intense watertight subdivision between main transverse watertight bulkheads.

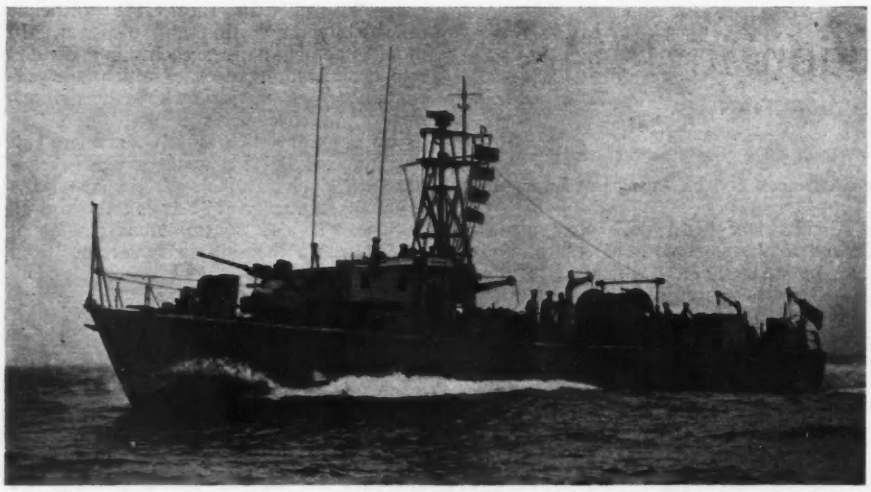
All important machinery is duplicated and self-contained. Stores are dispersed forward and aft. Important services such as the ring main for the distribution of electrical power and the fire main for providing fire fighting water, can be duplicated by means of emergency "runs." In short, the principle followed is duplication and dispersal. In order to combat damage each ship is divided into three sections, each of which is a self-contained unit provided with a local headquarters which controls repair teams within its own section. Centrally placed there is a position known as damage control headquarters, which is capable of receiving reports from all sections and assessing the overall damage. It also controls the transfer of liquids within the ship to correct heel and trim.

Bombs of the largest size can be carried, together with large quantities of aircraft rockets and ammunition for the strike and fighter aircraft. Each of the close-range defensive gun armament multiple power-operated mountings is controlled by its own director which, with precision radar, can automatically find and follow attacking aircraft even in fog or complete darkness. The ships are fitted to carry all airborne underwater equipment, such as sonobuoys, mines and torpedoes. New to H.M. ships are the ninety inflatable rubber lifesaving rafts, each capable of accommodating twenty men. This equipment has resulted in a considerable saving in weight and space.

The new "mirror landing sight" has already proved to be a great success. Basically, this aid consists of a large curved mirror which the pilot watches when he approaches the carrier from astern. A blob of light is projected into this mirror from a group of lights in the after part of the carrier, and if the pilot keeps this blob in line with a row of lights on either side of the mirror he can ensure landing at the appropriate angle to the deck. It is necessary to arrange for the mirror to remain at a constant angle regardless of the motion of the ship, and this is achieved by a gyro-mechanism perfected by naval gunnery experts.

The angled deck in the "Albion" "Bulwark" and "Centaur" is not the "full" angled deck which was conceived in the original British invention and pursued in subsequent American development and

All the ships of the "Ton" class of minesweeper are largely of wooden construction. They have a displacement of 360 tons with a length of 140ft between perpendiculars and 152ft overall and a beam of 28ft 9in. A number of them were completed in 1954. They have an armament of one 40mm Bofors A.A. gun forward and two 20mm A.A. weapons aft, and a complement of two officers and twenty-four ratings. The maximum speed of 15 knots is obtained from diesels turning two shafts. These new coastal minesweepers embody many novel ideas. Their construction incorporates the use of aluminium both for the framing and structural castings, the outer bottom being wood-planked. The hulls are thus largely of non-magnetic materials and, being of similar design, are capable of prefabrication. H.M.S. "Bildeston" is shown here



The many vessels of the "Ham" class of small minesweepers of wooden construction have a displacement of about 100 tons with a length of 100ft between perpendiculars and 106ft 5in overall and a beam of 21ft 2in. They are armed with a 40mm Bofors A.A. gun forward. Propulsion is by diesel and they are manned by two officers and eleven ratings. They are designed to operate in shallow waters such as rivers and estuaries. H.M.S. "Bodenham" is illustrated here

installation in much larger aircraft carriers and was oriented up to 10½ deg. off the centre line of the axial deck, but is an "interim" angled deck diverted obliquely 5½ deg. to port, which necessitated the removal of three twin 40mm gun mountings and the extension of flight deck plating on the portside amidships. It is understood, however, that as these new carriers come into dockyard for routine refit and modernisation at intervals in two or three years' time they will probably be provided with the full angled deck, depending upon the experience gained with the existing arrangement during the operational service of the ships.

The electrical installation in the three new carriers is the most intricate and comprehensive ever contrived in warships of their size. Peak demands for electricity are met by a generating plant with a total output of 3200kW. Each plant consists of eight electrical generators, each of 400kW capacity. Four of these generators are steam driven and four diesel driven, and each generator is capable of sustaining a 10 per cent overload for two hours. A 220V d.c. watertight ring main system is used for the distribution of the electrical energy, and supplies are tapped off this ring at convenient points round the ship through approximately 200 electrically operated circuit breakers. An emergency supply system is fitted for use in the event of damage.

While these ships were under construction a number of changes were made in the design with a view to improving the comfort of the ships' companies. The living quarters were arranged on the centralised messing or cafeteria system with two large dining halls close to the galleys, and with separate mess decks equipped with tubular steel furniture. Many of the living compartments are fitted with air-conditioned ventilation through systems almost entirely electrically driven so that the temperature can be maintained at a congenial level in any climate.

The "Albion," "Bulwark" and "Centaur" are officially known as of the "Hermes" class, but the name-ship herself will be completed a considerable time after her half-sisters—she was launched in 1953—and will, in fact, vary from them in many ways. It has been reported that the "Hermes" when finally completed will be known as the "Hermes" (Modernised) Class, as her design has been modified so much and she will be virtually of a different class. In many respects she will be more advanced than the earlier examples of the intermediate fleet carriers.

According to revised dimensions and armament officially announced by the Admiralty, the "Hermes" will now have an overall length of 745ft (only 8ft shorter than the large fleet aircraft carrier "Illustrious"), with a length between perpendiculars of 650ft and a waterline beam of 90ft, and will mount seventeen guns, of which the calibre was unspecified, but judging from the fact that this is only half the number previously announced (thirty-five) they will be 3in of the new rapid-firing, high-angle design instead of 40mm Bofors anti-aircraft guns. Her extreme width is expected to be about 130ft and her displacement is estimated to be 20,400 tons standard, increased to 26,000 tons at full load.

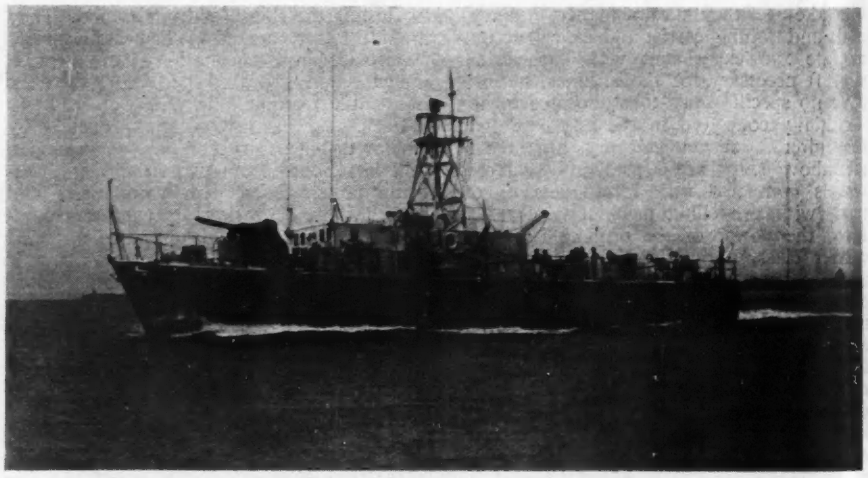
The new fleet aircraft carrier "Ark Royal" (Plate 1), began her contractors' sea trials on June 4, 1954. She differs from her sister ship "Eagle," as first completed, in that she has a lattice instead of tripod foremast, deck edge lift amidships, and different arrangement of guns, &c., on the port side, as eighteen guns were suppressed to provide for the angled deck and the side lift. She is still being finally fitted out and having adjustments made following trials, and is expected to join the Fleet in the near future.

Work is still suspended on the remaining two light fleet aircraft carriers which constitute the back-log of the second world war emergency programme, namely, the "Hercules" and "Leviathan." According to the 1954–55 Navy Estimates, however, the armament of the "Hercules" and "Leviathan" has been revised and they will now have twenty-five guns instead of the thirty-two 40mm Bofors anti-aircraft pieces officially announced a year previously, which suggests that the ships may eventually be resumed with provision made for the installation of the angled deck.

Cruisers

It was also stated in the 1954–55 Navy Estimates that constructional work on the three long-delayed light cruisers of the "Tiger" class begun about thirteen years ago remained suspended, although work in relation to the preparation of equipment was being progressed, and that the future armament and equipment of these ships was dependent on research then in progress, but on October 15th the First Lord of the Admiralty revealed that the construction of the "Blake," "Defence" and "Tiger" was to be resumed.

The keel of the "Tiger" was laid at the Clydebank Yard of John Brown and Co., Ltd., as long ago as October 1, 1941, and she was launched on October 25, 1945; but work upon her was stopped in July, 1946, and she was laid up at Dalimuir. The "Defence" was begun on June 24, 1942, by Scott's Shipbuilding and Engineering Company, Ltd., Greenock, and she left the stocks on September 2, 1944, but construction in her, too, was suspended after the war and in this case the contract with the builders was cancelled, and she was laid up in the Gareloch. The "Blake" was laid down by the Fairfield Shipbuilding and Engineering Company, Ltd., Govan, Glasgow, on August 17, 1942, and she slid down the ways on December 20, 1945, but she was also stopped in 1946 and she was laid up at Greenock. With a standard displacement of 9550 tons and a full load displacement of 11,700 tons, all three ships have a length between perpendiculars of 538ft, an overall length of 555ft 6in, a beam of 64ft and a maximum draught of 21ft. As originally designed they were to have had a main armament of nine 6in guns



The eleven boats of the "Ley" class are similar in displacement and dimensions to the vessels of the "Ham" class but are of composite instead of wooden construction and have a considerably different layout and appearance as regards superstructure. We illustrate H.M.S. "Dingley"

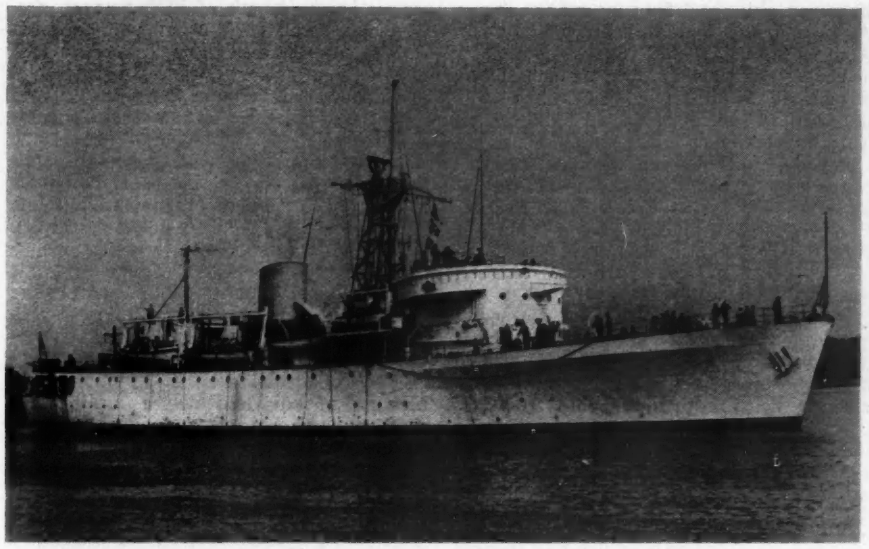
in three triple turrets, two forward and one aft, and a secondary battery of ten 4in anti-aircraft weapons, together with smaller A.A. pieces and six 21in torpedo tubes, but this entire armament has been suppressed in favour of four 6in guns in twin mountings and twelve 3in anti-aircraft weapons, which on paper appears to be inadequate as compared with her forebears and foreign contemporaries. But the 6in guns will have a rate of fire practically three times that of any existing gun of the same calibre now in service and will deliver some 5 tons of shell on a target every minute at a range of 13 miles: they will be directed by the latest fire control equipment which reaches out far beyond the range of the guns themselves and which will be equally effective under both visual and blind conditions: they can be used against both aircraft and surface targets, and by radar, through an electronic "brain," the guns will be automatically locked on to any target. And the anti-aircraft armament of the "Tiger" class will consist primarily of the new high rate of fire 3in, 70 calibre guns which will be coming into service in the near future. This new 3in gun has a rate of fire comparable with that of heavy machine guns. The new cruisers will be protected by 3in to 4in side armour belts, 2in turrets and 2in deck. The main propelling machinery comprises four Admiralty three-drum boilers and Parsons geared turbines turning four shafts and developing an aggregate of 72,500 s.h.p., equal to a speed of 31·5 knots.

The Admiralty announced on October 23rd that the "Tiger" will be completed by John Brown and Co., Ltd., Clydebank, the original builders, and the "Blake" by the Fairfield Shipbuilding and Engineering Company, Ltd., Govan (original builders); but the "Defence" will be completed by Swan, Hunter and Wigham Richardson, Ltd., Wallsend on Tyne. Their tentative completion date is 1957.

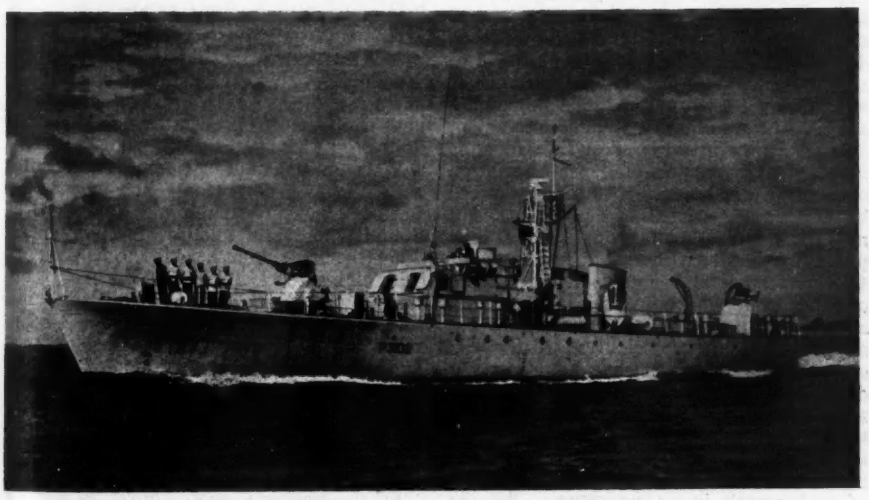
"Daring" Class Ships

H.M.S. "Diana" (ex-"Druid"), the last of the eight ships of the "Daring" class ordered during the war, which represent the ultimate British development of the destroyer, was accepted into H.M. Service, having been almost seven years under construction. Built by Yarrow and Co., Ltd., Scotstoun, she was laid down on April 3, 1947, launched on May 8, 1952, and completed on March 19, 1954. With a standard displacement of 2610 tons and a full load displacement of 3360 tons, she has an overall length of 390ft, a length between perpendiculars of 366ft, the broad beam of 43ft and a mean draught of 12ft 9in. Her armament consists of six 4·5in dual purpose guns in three twin turrets, two forward and one aft, six 40mm A.A. weapons, ten 21in torpedo tubes in two pentad nests, and a squid-type, triple-barrelled anti-submarine mortar.

The main propelling machinery comprises two Babcock boilers and two sets of Parsons type double-reduction geared turbines of advanced English Electric Company design, turning two shafts and designed to develop an aggregate of 54,000 s.h.p., equal to a speed of 34·75 knots. Her electrical installation operates at 440V, three phase, 60 c/s. Her hull is of all-welded construction and the habitability of the accommodation spaces is of a high standard, with all-electric galleys, modern laundry and bathrooms, for a complement of sixteen officers and 281 ratings. The destroyer, as exemplified by the "Diana," has reached its highest expression in the Royal Navy, but bigger destroyers and even larger destroyer leaders and destroyer-type escort vessels are being built by other countries.



The first survey ship to be equipped with a helicopter flight deck and hangar was finally completed and accepted into naval service on March 29, 1954. With a standard displacement of 1565 tons and a full load displacement of 1885 tons, the "Vidal" is the largest vessel built from the keel up as a survey ship for the Royal Navy. Officially described as the first of a new type, she has a length between perpendiculars of 297ft, an overall length of 315ft and a beam of 40ft with a draught of 10ft 6in



H.M.S. "Aberford" is one of a class of vessels specially designed for detecting, locating and destroying submarines, in the approaches to defended ports. Their armament includes a squid anti-submarine mortar, or 40mm anti-aircraft gun, depth charge release gear and flares, and modern electronic equipment is used in association with their weapons. They have a displacement of 110 tons, a length of 110ft between perpendiculars and 117ft 3in overall and a beam of 20ft

New Frigates

We turn from the foregoing units outstanding from the 1939–45 emergency war programme to new ships of the post-war naval rearmament programme initiated on the outbreak of the Korean war in 1950. Twenty-seven frigates were in various stages of construction or prefabrication during the year. They are of four different types: six are of the 1st rate or "quality" anti-submarine type named after seaside resorts and known as the "Whitby" class; twelve of the 2nd rate or "utility" anti-submarine type named after famous naval captains of the past and known as the "Blackwood" class; five of the anti-aircraft type named after big cats and known as the "Leopard" class, and four of the aircraft direction type named after cathedral cities and known as the "Salisbury" class.

Of the latter class, H.M.S. "Salisbury," the first new frigate and the first warship of substantial size in the post-war programme, which includes nothing larger than a frigate, was nearing completion at the end of the year. Laid down on January 23, 1952, she was launched at H.M. Dockyard, Devonport, on June 25, 1953, with propelling machinery supplied by Vickers-Armstrongs, Ltd., Barrow-in-Furness. Her three sister ships are the "Chichester," being built and engined by the Fairfield Shipbuilding and Engineering Company, Ltd., Govan; the "Llandaff," under construction at the Hebburn-on-Tyne Yard of R. and W. Hawthorn Leslie and Co., Ltd.; and the "Lincoln." The construction of these ships is all-welded and largely prefabricated, and they will have highly developed electronic equipment for their aircraft direction role. They have a length of 330ft between perpendiculars and 340ft overall with a beam of 40ft, and their displacement is estimated to be about 1800 tons. They will

be armed with two 4·5in guns and two 40mm A.A. weapons and will be powered by Admiralty standard range diesel engines.

The first of the new type of anti-aircraft frigates is H.M.S. "Puma," which was launched on June 30, 1954, at the Greenock Yard of Scott's Shipbuilding and Engineering Company, Ltd., and has propelling machinery of the latest Admiralty design, manufactured by H.M. Dockyard, Chatham, and Polar Engines, Ltd., Glasgow, consisting of Admiralty Standard Range I heavy oil engines coupled to the propeller shafting through hydraulic couplings and oil-operated reverse and reduction gearboxes, the actual installation being by the shipbuilders. Engines of similar design are being used for driving the ship's electric generators, and these are made by Peter Brotherhood, Ltd. Her four sister ships are the "Leopard," laid down in H.M. Dockyard, Portsmouth, on March 25, 1953, with Vickers-Armstrongs, Ltd., Barrow-in-Furness, as the main machinery manufacturers; the "Lynx" and "Panther," under construction by John Brown and Co., Ltd., Clydebank; and the "Jaguar," being built at the Dumbarton Yard of Wm. Denny and Bros., Ltd. These new frigates are designed primarily for the protection of convoys against aircraft. They will also serve as a smaller type of destroyer in offensive operations, and in fact, now that Great Britain has stopped building destroyers known as such, this anti-aircraft type of escort vessel is the nearest approach to destroyers as we have hitherto conceived them that will be seen in the Royal Navy for some little time. They are all welded and the Admiralty announced that the structural arrangements represent the last word in the development of modern technique. It was also officially stated that the opportunity has been taken in their building to study the problems associated with rapid construction in emergency conditions. With a length of 330ft between perpendiculars and 340ft overall they have a beam of 40ft and are reported to displace about 1800 tons. They will be armed with four 4·5in guns in two twin turrets of the same type as the gun mountings in the "Daring" class and with gunnery armament control similar to that fitted in those ships, two 40mm A.A. weapons, and a squid anti-submarine mortar.

Four more anti-submarine frigates of the "Captains" class were launched during the year, and the number of this type now under construction was brought up to twelve. These are in the hands of five builders, who are each responsible for two or three ships. The first anti-submarine frigate to be launched for the Royal Navy since the end of the second world war, H.M.S. "Dundas," which took the water on September 25, 1953, is in an advanced stage of fitting out at the Cowes Yard of J. Samuel White and Co., Ltd., Isle of Wight, who also launched the "Grafton" on September 13, 1954, and are building the "Exmouth." The second ship of the type is H.M.S. "Hardy," which slid down the ways on November 25, 1953, at the Scotstoun Yard of Yarrow and Co., Ltd., of Glasgow, who also launched the "Keppel" on August 31, 1954, and have the "Malcolm" under construction. The "Blackwood" and "Duncan" are being built at the Woolston Yard of John I. Thornycroft and Co., Ltd., Southampton, while the "Murray" and "Palliser" are under construction at the Govan Yard of Alex. Stephen and Sons, Ltd., Glasgow. The remaining two ships of the class are the "Pellew," launched at the end of September, 1954, at the Wallsend-on-Tyne Yard of Swan, Hunter and Wigham Richardson, Ltd., and the "Russell," launched by the same firm on December 10, 1954. All twelve vessels have a length of 300ft between perpendiculars and 310ft overall with a beam of 33ft, and the displacement is about 1300 tons. The armament comprises three Bofors guns, four 21in. torpedo tubes in two twin mountings (in this respect these frigates are like small destroyers), and two of the improved squid-type three-barrelled anti-submarine mortars of the same design as those fitted in the fast anti-submarine frigate "Rocket" (converted from a fleet destroyer). Known as "limbos," these weapons can be trained over a wider arc than previous kinds of anti-submarine mortars and each can fire with great accuracy a pattern of large projectiles which can be set to explode at a predetermined depth. The propelling machinery comprises Babcock boilers and a set of geared turbines of advanced design turning one shaft developing 15,000 s.h.p. equal to speeds of 21 to 22 knots. The turbines have been built by the shipbuilders in six of the class by the Wallsend Slipway and Engineering Company, Ltd., Wallsend-on-Tyne, in the "Pellew" and "Russell"; in the engine works of the Parsons Marine Steam Turbine Company, Ltd., Wallsend-on-Tyne, for the "Grafton" and "Malcolm"; and to English Electric Company design in the "Hardy" and "Keppel." All the ships are of comparatively simple construction and were built in prefabricated sections.

The first of a new type of six large and fast first-rate anti-submarine frigates for the Royal Navy were launched at mid-year. They are the "Torquay," built at the Belfast Yard of Harland and Wolff, Ltd., where the naming ceremony was performed on July 1, 1954, and where a sister ship, the "Blackpool," is to be built, and the "Whitby," which came off the stocks on July 2, 1954, at the Birkenhead Yard of Cammell Laird and Co., Ltd., who also have the "Tenby" under construction, these firms also being responsible for the main engines. The remaining two vessels, the "Eastbourne" and "Scarborough," are being built by Vickers-Armstrongs, Ltd., Newcastle on Tyne, with Vickers-Armstrongs, Ltd., Barrow-in-Furness, as the main machinery manufacturers. With an estimated displacement of approximately 2000 tons, all six ships will have a length of 360ft between perpendiculars and 370ft overall, with a beam of 41ft. The propelling plant consists of Babcock boilers and two sets of geared turbines of novel design turning two shafts and aggregating 30,000 s.h.p., equal to a speed of 30 knots. The armament will comprise two 4·5in dual-purpose guns, two 4in anti-aircraft pieces, and powerful anti-submarine weapons of post-war development with the latest underwater detection apparatus. The Admiralty has announced that, having been primarily designed for the location and detection of the most modern of submarines, these first-rate frigates will be fitted with specialised equipment of a new kind with steam propulsion of high power to give them the speed necessary for their important task and good sea-keeping qualities enabling the vessels to maintain a fast speed in rough seas. The ships are all welded, and it is officially stated that the structural arrangements have been specially designed to achieve the lightest possible structure, and the opportunity has been taken in their building to gain experience in welding procedures and arrangements calculated to conduce to rapid construction of such vessels in an emergency. All the new frigates will be of somewhat unorthodox appearance. Instead of the clean-swept profile forward from the break in the forecastle deck they will rise up in steps to a rather ungainly prow and right in the eyes of the ship will be a bulwark, nearly approaching the height of the bridge, which will serve to protect scientific apparatus no less than personnel against heavy weather.

New Submarines

The first new submarine to be launched for the Royal Navy since the last of the "A" class took the water in 1947 was H.M.S. "Explorer" at the Barrow-in-Furness Yard of Vickers-Armstrongs, Ltd. Of a new streamlined form designed to operate at high underwater speeds, her propulsive machinery, supplied by Vickers-Armstrongs, Ltd., is of novel design employing high test hydrogen peroxide plant. She has a length of 178ft between perpendiculars and 209ft 5in overall, with a beam of 15ft 8in. She is fitted with modern submarine escape arrangements, including the one-man escape chamber, and is being supplied with the most recent submarine escape breathing apparatus for use by the ship's company in the event of emergency. A sister ship, the "Excalibur," is under construction. Both submarines are largely experimental.

It was officially stated that the construction of the new type of fast submarine was continuing satisfactorily and, in addition, a number of submarines of an interim design, with a better performance than any predecessor, were being built. Six of the latter, with conventional propulsion, are reported to have been ordered, three from Cammell Laird and Co., Ltd., Birkenhead; two from Vickers-Armstrongs, Ltd., Barrow-in-Furness, and one from Scott's Shipbuilding and Engineering Company, Ltd., Greenock. Names reported are "Cachalot," "Grampus," "Narwhal" and "Porpoise." No details have been released, but they are expected to have a submerged displacement of approximately 2000 tons.

The first of the new and improved midget submarines, designated the "X 51," was launched at the Barrow-in-Furness Yard of Vickers-Armstrongs, Ltd., on October 1, 1954, and was completed for service. She is a boat of nearly 54ft in length and is propelled by diesel and electric machinery, the prime mover being by F. Perkins, Ltd., of Peterborough. She will have a complement of five personnel. Her three sister-boats are known as "X 52," "X 53" and "X 54." All were built at the same yard, and were designed for training and trials purposes.

Minesweepers

According to the 1954–55 Navy Estimates sixty-six coastal minesweepers of the "Ton" class (p. 29) were under construction. For most of these the manufacturers of the main machinery, standardised to simplify the maintenance problem, were Mirrlees, Bickerton and Day, Ltd., Stockport, but in two vessels, one built by Camper and Nicholsons, Ltd., Gosport, Hants, and the "Highburton," launched at the Woolston Yard of John I. Thornycroft and Co., Ltd., on June 2, 1954 (the first ship of her kind to be powered with high-speed Deltic diesel machinery), the engineers were nominated as D. Napier and Son, Ltd., of Acton. In addition to the main engine-room for the propelling machinery there is a separate generator room to develop the power for the electric sweep. Thornycroft was selected by the Admiralty to act as the "parent" firm for the production of working drawings for this type of vessel for supply to a group of builders.

Of the smaller version known as inshore minesweepers, sixty-one were under construction according to the 1954–55 Navy Estimates. The main machinery manufacturers for most of these were Davey Paxman and Co., Ltd., Colchester, or Ruston and

Hornsby, Ltd., Lincoln, under licence from the former company, but Fodens, Ltd., Sandbach, Cheshire, were the engineers for three of the vessels being built by J. Samuel White and Co., Ltd., Cowes, Isle of Wight, who are the parent firm for the inshore minesweeper which, under a wide-spreading allocation scheme wisely devised by the Admiralty that will be of immense value if larger numbers of these craft are required in a war emergency, are being constructed by twenty-two smaller shipbuilding yards and boat and yacht building firms in the United Kingdom. The inshore type of minesweepers are subdivided into two classes, the "Ham" class and the "Ley" class, illustrated on page 30. They are all flush decked and funnelless in contrast to the new coastal minesweepers which have a forecastle breaking abreast the funnel just abaft of amidships.

Patrol Boats and Survey Ships

The Admiralty announced that H.M. Fast Patrol Boat (Convertible Motor Torpedo Boat/Motor Gun Boat) "Dark Hunter," officially described as the first of a new class powered by the Napier "Deltic" engine, which has a very high performance, was launched at the Fife Yard of James N. Miller and Sons, Ltd., St. Monance, on March 18, 1954. These "Dark" class "short" boats differ from their "Gay" class half-sisters in that they are of composite construction, aluminium alloy being used for all the framing and for the deck. They also vary in dimensions, having a length of 67ft between perpendiculars and 71ft 4in overall with a beam of 19ft 5in and a draught of about 5ft. The boats are constructed so that they can be armed either as gunboats or as torpedo boats. In the role of gunboats each will mount either a 4·5in gun and a single Bofors 40mm A.A. weapon, or two single Bofors pieces. As torpedo boats they will be armed with four single 21in above water torpedo tubes and one 40mm A.A. gun.

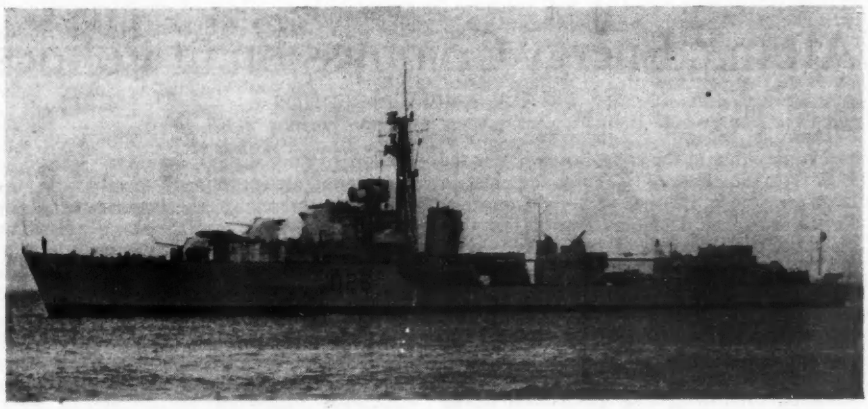
The forerunners of this new type of "mosquito" craft were the group known as the "Gay" class, of which a number were completed during the year.

Several more of the novel submarine chasers of the "Ford" class (illustrated on page 31) officially known as seaward defence boats, were accepted into service during the year.

A new survey ship, H.M.S. "Vidal" (illustrated on page 31) was completed later than originally scheduled. But she is unique in that while the requirements of the Hydrographer of the Navy have, since the war, been met by converting frigates during the building stage into survey ships, and for many years before the war by adapting sloops for surveying duties, the "Vidal" was from the start designed by the Admiralty for hydrographic surveying and chart production, and the Royal Dockyard at Chatham was responsible for both her hull and main machinery.

H.M.S. "Britannia"

The medium-sized hospital ship which the Admiralty announced in the Autumn of 1951 would be put into the naval construction programme and which would be used in peace time by His Majesty King George VI as a replacement for his yacht "Victoria and Albert" (which, launched in 1899, was by then completely useless as a seagoing vessel, and is now being broken up), was accepted by the Admiralty from the builders, John Brown and Co., Ltd., at the beginning of 1954. It was fitted out and furnished in H.M. Dockyard, Portsmouth, just in time to proceed to Tobruk to convey Her Majesty Queen Elizabeth II and Admiral of the Fleet His Royal Highness The Duke of Edinburgh on their return from their Commonwealth Tour in May. The order for the Royal Yacht was placed in February, 1952, for completion in two years. All the structural plans for the "Britannia" were submitted to Lloyd's Register of Shipping and in the final form these plans were approved by both Lloyd's Register and the Admiralty.



Former orthodox fleet destroyer reconstructed and refitted for anti-submarine and minelaying duties. In addition to three 4·5in dual purpose guns in "A," "B" and "Y" positions and two squid, three-barrelled anti-submarine mortars in "X" position, she carries several anti-aircraft weapons and four 21in torpedo tubes, and has minelaying chutes at the stern. H.M.S. "Comet," illustrated here, has a displacement of 1710 tons standard

Aircraft Carrier Reconstruction

Turning from newly-built ships to vessels being reconstructed, work proceeded apace in 1954 on the large fleet aircraft carrier "Victorious," which is being completely rebuilt. Her rejuvenation constitutes the biggest warship reconstruction job ever undertaken in Great Britain. She was taken in hand by H.M. Dockyard, Portsmouth, in March, 1950, but her modernisation and conversion is so extensive and so many new ideas are being incorporated in her to keep abreast of current and anticipated developments which will enable her to operate the largest, fastest and heaviest naval aircraft of the present and future that it is now estimated she will not be completed for trials until 1957. She will be much longer, wider, higher and heavier than before, and will be equipped with the full angled flight deck, two of the new steam catapults and the deck edge lift. When her transformation is completed she will be, to all intents and purposes, a new warship and an aircraft carrier of much more formidable type. The "Victorious" was originally laid down in 1937, launched in 1939, and completed in 1941 by Vickers-Armstrongs, Ltd., Walker-on-Tyne, with propelling machinery by the Wallsend Slipway and Engineering Company, Ltd., when she had a standard displacement of 23,000 tons with a length of 751ft, a beam of 95ft 9in, and a draught of 29ft 3in. She was armed with sixteen 4·5in guns, seven 40mm anti-aircraft weapons, forty-four 20mm A.A. pieces and forty 2-pounders, and she had a capacity of fifty-four aircraft. Six three-drum boilers and Parsons geared turbines turning three shafts and aggregating 110,000 s.h.p., gave her a speed of 31 knots. According to amended figures released by the Admiralty in 1954, however, her reconstruction involves increases of 7000 tons displacement, 35ft in length, 6ft 9in in hull beam and 1ft 9in in draught. When she emerges from dockyard hands she will have an estimated displacement of 30,000 tons with a length of 786ft, a beam of 102ft 6in and a draught of 31ft. She will carry seventy-two aircraft and will be armed with sixteen 4·5in guns and fifty smaller A.A. weapons.

Destroyer Conversions

Of the forty-five fleet destroyers of the war emergency classes scheduled to be converted into fast anti-submarine frigates thirty-five had been reconstructed or taken in hand for conversion by the end of 1954. Twenty-two fleet destroyers were fully converted or taken in hand for large-scale reconstruction on similar lines to the prototypes "Relentless" and "Rocket."

In addition, eleven destroyers were converted or taken in hand for conversion on a limited scale into fast anti-submarine frigates.

The former destroyers "Paladin" and "Petard" have also undergone limited conversion to fast anti-submarine frigates on similar lines to the "Orwell," but the taking in hand of her sister ship "Opportune" was postponed for a while. These four are somewhat smaller vessels with a standard displacement of 1540 tons and full load displacements of 2315 to 2400 tons, an overall length of 345ft, a beam of 35ft and a draught of 15ft 8in. These ships originally had an armament of four old pattern 4in guns, twelve small A.A. pieces, and eight 21in torpedo tubes, but they now mount two 4in guns, two squids, two 40mm A.A. weapons, and four 21in torpedo tubes.

An even simpler and quicker form of conversion to fast anti-submarine escort vessels is embodied in the recent modernisation of several destroyers of the "C" group ("Ch" and "Co" classes). They have had "X" gun suppressed and replaced by two squid anti-submarine mortars, and in most respects are comparable with the "T" class limited conversion fast anti-submarine frigates, although in this case the destroyer designation has been retained. They are multi-purpose vessels which, with their modern 4·5in guns, retain much of the surface-fighting power of the destroyer, but at the same time they are anti-aircraft vessels, anti-submarine escorts, torpedo boats and minelayers. The "Chaplet" and "Comet" (illustrated above) have minelaying sterns.

A smaller but no less interesting reconstruction project was the conversion of the steam gunboat "Grey Goose" into a gas turbine fast patrol boat and seaward defence vessel by the installation in her of two Rolls-Royce prototype "R.M.60" gas turbine engines of a design similar to that of aircraft propulsion units. Her two new Rolls-Royce gas turbines develop a total of 12,000 s.h.p. She was converted by Vosper, Ltd., Portsmouth, being completed for trials in 1954.

(To be continued)

Atomic Energy Commission in Politics

BY OUR AMERICAN EDITOR

There is general agreement on Capitol Hill to-day that in the course of last year the U.S. Atomic Energy Commission lost a large measure of its once very great prestige. Republicans and Democrats alike feel that the confidence formerly placed in the agency has been weakened by internal political friction which has grown to serious proportions. How did the agency get involved in partisan politics? Actually, the present situation arises from a complex of conflicting viewpoints—ideological, political and scientific. It can best be understood in the light of the agency's history. In the beginning, the A.E.C. went through a growing-up process. Atomic science was raised to its pre-eminent position by the atomic bomb. The concentration on that "crash" programme precluded politics or internal strife of any kind. Dedicated men worked in the inner sanctums of laboratories and works whose nature baffled the man in the street. The war jolted the scientists out of their "shell" and they emerged as vocal citizens—"citizens of the whole," as it has been said, rather than "citizens in the part." Their concern was with the dreadful effects of their handiwork, which also, by their hands, might be turned to the peacetime use of all mankind. This emergence, in the opinion of many observers, laid a basis for clashes outside the scientific arena. The dispute over "who did or who did not" support the hydrogen bomb gave such impetus to the then unseen schisms that the ultimate injection of partisan politics into the atomic programme was advanced by years. The withdrawal of security clearance from Dr. J. Robert Oppenheimer further advanced the division. Currently, the Dixon-Yates private power generating pact, which was instituted at the direction of President Eisenhower, has served to plunge the whole atomic community into the political arena. It now would appear, as David Lilienthal, a former chairman of the Commission, observed recently, that a fundamental transformation is in process in the very character of the A.E.C. There are many on Capitol Hill who disagree, however, with his thesis that the change does not appear to be a deliberate one. This is in the nature of a partisan charge, but must be considered in light of the boiling controversy. In addition to a clash of personalities, there are fundamental disagreements on two major political issues—the Republican Administration's security programme and the issue of public versus private power generation.

Rear Admiral Lewis L. Strauss admittedly has been in a difficult position lately as a result of his dual role as chairman of the A.E.C. and as President Eisenhower's personal adviser on atomic matters. It is only natural, therefore, that he alienated to some degree his associates on the Commission who have openly wondered about his influence on the President. Other personalities involved in the present controversy are equally strong. Thomas E. Murray, an A.E.C. member, who clashed publicly with his chairman before the Joint Congressional Committee on Atomic Energy in November last, is a production engineer whose professional career matches that of Admiral Strauss, but whose political experience is less than the chairman's. Essentially, both these personalities are conservative, as contrasted with the so-called liberal point of view. Theirs is a "private enterprise" view point, which also can be attributed to Joseph Campbell, another A.E.C. member. The two new members of the Commission, Dr. Willard Frank Libby and Dr. John von Neumann, are prominent members of the scientific community, the majority of whose members are upset over the manner in which the Administration's loyalty-security programme seems to operate. The immediate past members of the Commission clashed with Admiral Strauss on many counts, too. But these were conflicts of personality and ideology rather than politics. It thus can be seen readily that the continuing difficulties within the A.E.C. are an intermingling of many forces, triggered by the intense personality who occupies the chair and once sought to have atomic law clearly define his position as the Commission's "principal officer." In so doing, he precipitated a partisan row on Capitol Hill that served only to intensify the political fight and caught the other A.E.C. members up in the partisan battle The result of this public brawling has been the labelling of the members of this supposedly non-partisan agency as "Democrats" or "Republicans."

President Eisenhower told his news conference in November that any agency working for the Government should be non-political, of course, and if there was a political controversy over Dixon-Yates it was not of his making. Yet the very heart of the matter engaging the time of the Congressional committee is that the President directed one agency to do something for another agency. This alone is sufficient to arouse partisan ire. What is to be the ultimate outcome of the conflicts? In some quarters it is believed that by naming scientists to the Commission the President has sought to appease the scientific community that has rallied against his security programme. If the Administration's projected move of Mr. Campbell to the office of Controller-General comes about, the President will have an opportunity to consolidate what some consider a gain in his effort to check the controversy over the A.E.C. On Capitol Hill, however, the fire burns hot. Informed opinion considers certain a Congressional investigation of the genesis of the Dixon-Yates private power generation deal. One suggested approach is a resolution in the now Democratic-controlled Senate that will cover the Dixon-Yates affair completely and in all likelihood inquire deeply into the motivations of all those who have been involved in negotiating the private power pact. Some partisans believe that Mr. Murray's accusations—that the Dixon-Yates proposal diverted the A.E.C. from its primary mission of atomic development—alone justifies a Congressional investigation. The appeal for bipartisanship is a two-way street and as far as the "A.E.C. in politics" is concerned, a settlement will come only if the partisans meet on the same street. Thus, the President and the now Democratic leadership of the Congress are faced with equal responsibilities. Meanwhile, as has been pointed out by both sides, a dangerous tendency continues that can only lead to continued political sniping, the very opposite of what calm heads in both parties appear to want at A.E.C. headquarters.

Gas Turbines in 1954

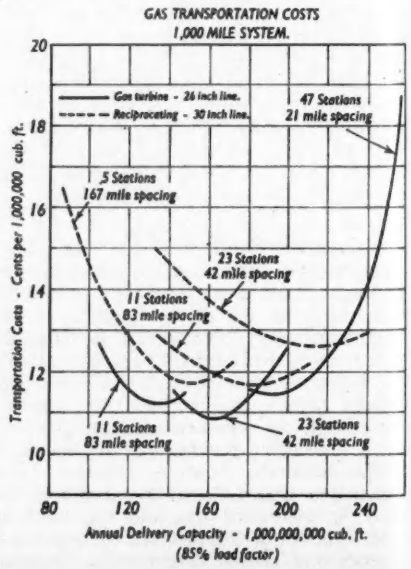
THE major American manufacturers of gas turbines continued during the past year to concentrate on the production, in considerable numbers, of relatively simple engines. The accent now seems to be on finding the largest possible number of applications in various fields for the least number of different models.

At the present time, about 100 commercial gas turbine power plants, ranging from 1MW to 15MW, are in operation or in process of manufacture in the United States. These installations represent a total capacity of approximately 400MW, and the earliest units have now been in operation about five years. The gas turbine power plants now installed or being manufactured are for one of the following four applications, listed in descending order of present magnitude of utilisation :—(1) Natural gas transmission, (2) electric power generation, (3) gas turbine-electric locomotives, and (4) mechanical drive for process purposes.

Natural Gas Transmission

The economics of the gas turbine power plant for natural gas transmission are not all dependent on the characteristics of the gas turbine itself. In evaluating the gas turbine, it must be compared with the reciprocating engine on an overall basis. Unlike the reciprocating engine, the gas turbine lends itself to driving a high-speed centrifugal or axial compressor for natural gas compression. The centrifugal natural gas compressor is capable of operating efficiently at lower pressure ratios and higher flows than a reciprocating compressor. In the United States reciprocating engine compressor stations are usually spaced 75 to 100 miles apart and the gas is compressed between a compression ratio of 1·5 : 1 to 2 : 1. These high compression ratios heat the gas sufficiently to make it economical to cool it before returning it to the line in order to maintain line capacity. By reducing the station spacing, lower compression ratios are possible, and the need for gas cooling is eliminated. The horsepower necessary to transport a given amount of gas thus can be reduced 25 to 40 per cent by closer station spacing.

Several studies have been made to determine the installed cost comparison between the gas-turbine-driven centrifugal compressor and the conventional direct-driven reciprocating units. One study was made using these drives to power a transmission line 1000 miles in length. This study was based on the assumption that complete spare units would be available to maintain the design flow capacity in the event of any one unit breaking down. The accompanying graph shows the comparison of transportation costs between a gas-turbine-powered line of 26in O.D., $^{11}/_{32}$in wall pipe and a reciprocating compressor-powered line of 30in O.D., $\frac{1}{4}$in wall pipe. The



Comparison of gas-turbine-powered and reciprocating engine-powered natural gas transportation

gas turbine station spacing is approximately one-half that of the reciprocating compressor stations, and for the gas-turbine-powered 26in line the best possible gas delivery is approximately the same as that of a reciprocating engine-powered line of 30in O.D. In summarising this study it was found that, for a delivery capacity of 170,000 million cubic feet annually, with an 85 per cent load factor, a 26in O.D. pipeline with gas turbine centrifugal compressors required about 8,000,000 dollars less capital investment, 60,000 fewer tons of steel, and resulted in a reduced annual cost of about 1,360,000 dollars, or 0·8 cent per 1000 cubic feet. As a result of such studies, it appears that the gas turbine can be used economically to drive centrifugal compressors on natural gas transmission lines 20in in diameter and larger.

Electric Power Generation

Commercial gas turbine power plants for electric power generation are now being employed in the United States within a range from 1250kW to 15,000kW. The thermal efficiencies of these units vary from 16 per cent for the simple open cycle to 28 per cent for the compound open cycle with intercooler and regenerator. The present American gas turbine power plants are designed for a maximum turbine inlet temperature of 1350 deg. to 1450 deg. Fah., and it is apparent that, from a thermal efficiency standpoint alone, such gas turbine power plants cannot compete with steam turbine power plants. In all the comparisons which have been made, a smaller fuel consumption and a greater fuel selectivity have continued to be the major advantages of the steam turbine plant over the gas turbine plant.

From the best available data it was recently estimated that the installed cost of a gas turbine power plant in America is approximately 80 to 90 per cent of that of a comparable steam turbine power plant. A representative American 5000kW, simple open cycle, gas turbine power plant at present can be installed at a total cost of approximately 175 dollars per kilowatt, and can be operated with one superintendent and five operators.

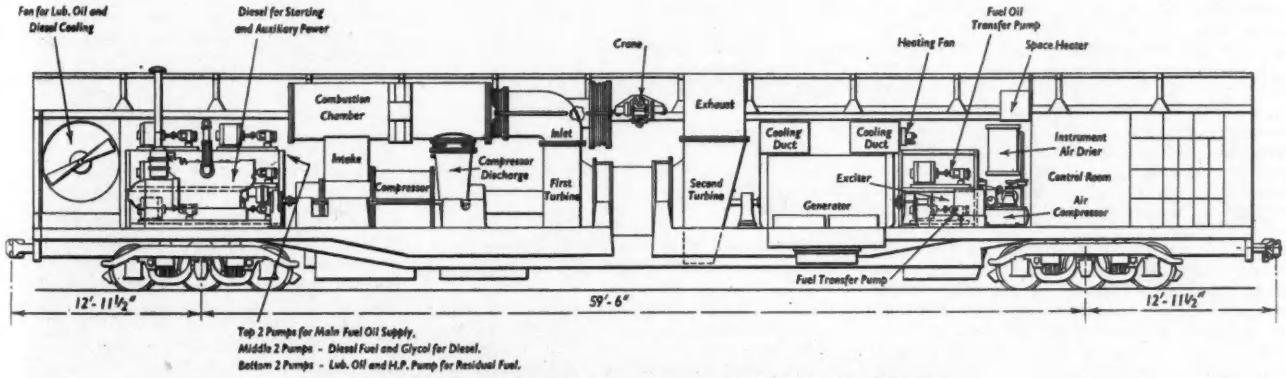
Mobile Electric Power Generation Plant

The Bureau of Yards and Docks, of the U.S. Navy, is building an interesting mobile electric generating station which employs a 4500kW gas turbine as prime mover. The entire power plant, which is shown diagrammatically in the accompanying illustration, is contained in a railway wagon, 85ft 5in long, 10ft wide and 14ft 6in high. It has been designed to be rugged enough to be attached to any railway train and hauled anywhere in the United States without special care. It can go into operation within twenty-four hours of its arrival. The plant is designed to supply power in emergencies anywhere in the country. It is believed that utility companies, especially those with widespread systems, may find similar plants useful as they cost little more than a stationary steam generating plant of the same capacity and have the advantage of mobility. A major problem involved in designing the wagon was to make it so shock resistant that it could be moved in any freight train without damage to the delicate generating equipment. All equipment mountings and supports were designed to withstand shock loadings of 2*g* in any direction.

The gas turbine power unit is an open cycle machine having independent compressor-drive and power-output turbines. It is rated at an output of 4500kW at an altitude of 1000ft with an ambient temperature of 70 deg. Fah. The turbine inlet temperature under these conditions is expected to be 1350 deg. Fah. The power unit has a single axial flow compressor, which is driven by a two-stage, high-pressure turbine at 5000 r.p.m. at full load. Air flows from the compressor discharge to a single combustor of the counter-flow design, which is mounted horizontally above the compressor. High-temperature gas from the combustor flows to the nozzles of the high-pressure turbine from which it is discharged through a flexible duct to the low-pressure or power turbine. The power turbine, which also has two stages, is directly connected to the generator through a flexible coupling. As it is independent of the compressor shaft, no gearing is needed to drive the alternator on either a 50 c/s or a 60 c/s system. On 60 c/s systems the power turbine runs at 3600 r.p.m.; on 50 c/s systems it runs at 3000 r.p.m.

In operating the plant, any distillate fuel oil may be used at present. It is hoped that in the near future modifications also will permit the use of residual fuels. The fuel supply system of the wagon, therefore, has been designed for handling them. Provision is made for heating of the fuel by the turbine exhaust to temperatures suitable for injection into the combustor. Of the three burners in the combustor any one can be shut off and withdrawn from the combustor without shutting down the plant. The burners have two concentric fuel sprays to ensure good atomisation over a 10 to 1 range of fuel flows.

The constant-speed governing system of the plant utilises pneumatic control equipment having a pneumatic speed transmitter, driven from the power turbine shaft, which sends a pressure signal proportional to revolutions per minute to the speed controller. The speed controller has an adjustable droop characteristic; it may thus load the turbine proportionally when operating the generator in parallel in any given system. Emergency over-speed trips are provided on each turbine shaft. The main alternator is an air-cooled machine capable of delivering full turbine capacity at frequencies of either 50 or 50 c/s. The design voltage at 60 c/s is 12·5kV, while at 50 c/s it is 10·4kV. Switching of the alternator is facilitated by a 500MVA main circuit breaker. The capacity of the breaker was determined by the possibility that the unit may be tied in to large power systems in the course of its service. For starting the main engines and supplying auxiliary power, a six-cylinder, two-cycle diesel engine will be installed to drive a four-pole alternator rated at 60kW through a shaft extension. The auxiliary equipment of the mobile power station includes a main fuel supply, including a 500-gallon day tank, a transfer pump capable of drawing fuel from other tanks, and an auxiliary diesel engine fuel system which also contains a 500-gallon tank. The lubrication system is conventional, bearing oil normally being supplied by a pump driven from the main turbine shaft. A battery and a battery charger make up a d.c. system for circuit breaker control and emergency operation of some of the auxiliaries. The controls and major operating and recording instruments have been centralised at a panel in a control room near one end of the wagon.



Mobile gas-turbine-driven electric power generation plant for the U.S. Navy

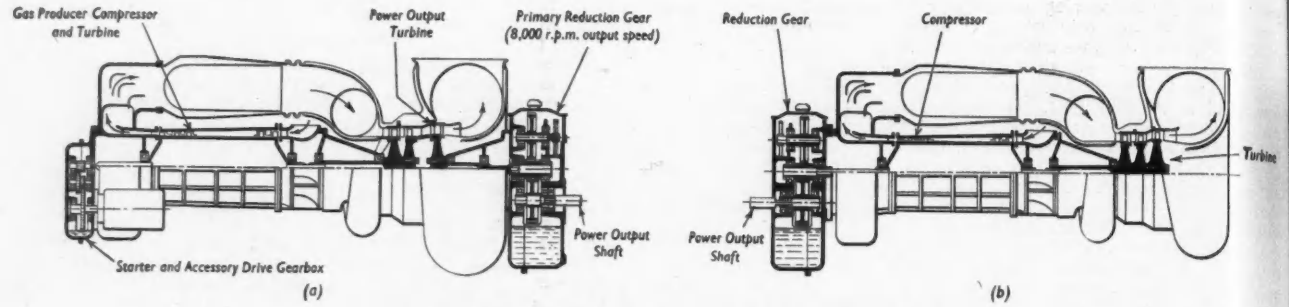
Marine Propulsion Applications

The smaller "portable" gas turbines continue to receive much attention in the United States, and the "Jupiter" engines developed for the U.S. Navy Bureau of Ships by the Solar Aircraft Company are representative of this trend. From the beginning, this series of gas turbines was designed for use in either of two forms. One is as a simple, single-shaft unit, with a high flywheel effect for driving such loads as a.c. electric generators, where sudden load changes can occur and speed or frequency transients must be minimised. The other use is as a two-shaft or split-wheel unit offering torque multiplication, and employed in such applications as boat or vehicle propulsion. The two original versions of the "Jupiter" engine are illustrated schematically in one of the drawings overleaf. It will be noted that the compressor is an axial ten-stage unit, that a single-can combustor is employed and that the turbine is made up of three axial stages. In the single-shaft version, model "T–520," (Plate 7 facing page 36) the three turbine stages are bolted together and the power output is taken from the compressor end. In the two-shaft version, the model "T–522," the third turbine stage is separated mechanically from the other two, and the net output power is extracted from the third stage.

The shipboard applications, for which these engines were originally designed, dictated a design having relatively long life, as compared with most other small gas turbines in use to-day. Accordingly, the rotative speeds, stresses and operating gas temperatures are relatively low, and the structural members are designed to carry the high shock loads that can occur in combat vessels. While the use of the multi-stage axial-flow compressor and turbine adds to the complexity of the engine, as compared to single-stage centrifugal machines, the fact that rotative speeds and stresses are lower allows a less stringent quality control of surface finish and tolerances, thus offsetting to some degree the cost advantage of the simpler units which operate at high speeds and temperatures. Further, the more efficient multi-stage axial units provide significant savings in fuel costs. Over the past two years, some 1500 hours of development testing have been accumulated on the "Jupiter" single- and two-shaft engines, and an operating life between overhauls of 800 to 1000 hours, depending on the application, is indicated. A "Jupiter" engine was the first gas turbine ever installed in an American naval ship, and a number of these engines are now in service aboard U.S. Navy vessels.

Aircraft Starting Applications

With the advent of the air turbine starter for cranking large turbo-jet and turbo-prop engines,



Arrangement of constant speed and variable speed "Jupiter" gas turbines

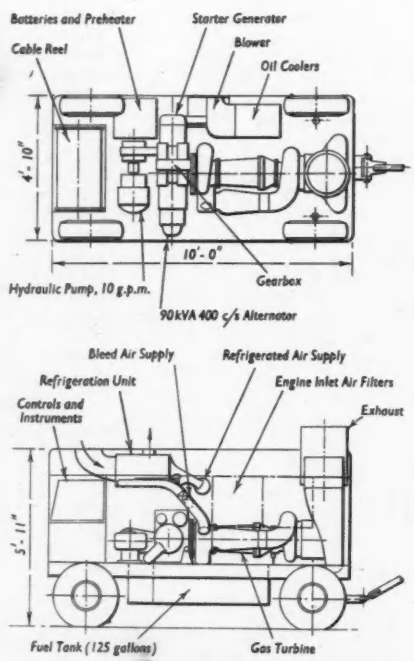
(a) Solar model "T.522" variable output speed gas turbine (b) Solar model "T.520" fixed shaft, constant speed gas turbine

it became evident that if the gas turbine could be adapted to supply all or part of its output in the form of compressed air, a new field of application would be opened in mobile ground power units for starting turbine-propelled aircraft. The fact that the "Jupiter" series engines were designed for relatively long life in sea level applications is considered to be a competitive advantage in this field, since all other gas-turbine-driven ground power units in use to-day incorporate prime movers originally designed for airborne applications. The possibility of obtaining compressed air by driving a separate compressor from the power turbine of the two-shaft version of the "Jupiter" engine was examined, but was discarded in favour of a compressor air bleed on the single-shaft engine, because (1) of the complexity, cost and weight involved in furnishing a separate compressor; (2) the separate compressor would inherently have less efficiency, and (3) in a multi-purpose ground power unit, where a.c. electric power and/or hydraulic power is supplied in addition to compressed air, the constant-speed operation of the separate compressor would involve a substantial penalty in fuel economy. It was felt that the primary disadvantage of the air bleed approach, i.e. the more difficult starting and acceleration due to the problem of compressor surge, could be satisfactorily handled by suitable air bleed during the starting cycle.

A decision having been made to concentrate on adapting the single-shaft engine into a gas turbine compressor, the problem resolved itself into reducing the capacity of the turbine to accommodate the lower gas flow passing through the turbine when a substantial quantity of air is bled from the compressor discharge. The reduction of turbine flow area could be accomplished by reducing the angle setting of the nozzle vanes and rotor blades while maintaining the existing vane and blade length or by maintaining the existing angles and reducing the length. The double wall construction used in the turbine, i.e. an outer shell for structural support and a series of inner rings or shoes to reduce the temperature of the outer shell and minimise differential expansion between the rotor tips and the stator, made the latter adaptation far easier from the standpoint of tooling cost, since it involved only making the turbine casing inner rings deeper and cutting off the tips of the rotor and nozzle assemblies. This method also had two other important advantages. Little or no change would occur in turbine efficiency, thus decreasing the amount of additional development work and enabling the accurate prediction of performance of the air bleed engine. Furthermore, the shorter turbine blades would mean lower rotational stresses in the turbine, which would permit higher operating speeds with the same safety margin, or a longer life at the existing rated speed.

The present aircraft starting unit was designed to furnish to following representative requirements of the aircraft on the ground :—Compressed air for engine starting, 2·5 lb per second at 53 lb per square inch absolute; electric power, 80kVA at 400 c/s, 120/208V; hydraulic power, 10 gallons per minute at 3000 lb per square inch; Cooled or heated air for flight deck air conditioning, 2000 lb per hour at 40 deg. or 150 deg. Fah. respectively.

The first three requirements can be concurrent; the air for flight deck conditioning can be interrupted during engine starting. It should be noted that although the present American military cargo aircraft carry enough auxiliary power equipment on board to be completely self-sufficient when on the ground, it is generally conceded that overall maintenance costs will be reduced if ground power requirements are handled by an external piece of equipment. It should also be noted that the rated air pressure required by the starter is significantly less than can be furnished by the ground support unit, even when due allowance is made for pressure drop in the supply duct. The probable reason for this is that current air turbine starters were designed for use with relatively low pressure ratio gas turbine compressors employing centrifugal compression.



Arrangement of gas-turbine-powered aircraft ground support unit

The accompanying drawing shows the Solar ground power unit which was designed to fulfil the above requirements. It may be noted that a small right-angle reduction gearbox provides drives for a conventional 90kVA aircraft alternator and an industrial hydraulic pump, as well as a starter generator and other engine-driven accessories. The gearbox also incorporates the engine lubricating oil reservoir. The 28V d.c. output from the starter generator charges the starting batteries and drives a blower furnishing cooling air for the alternator and the oil cooler. Compressed air for aircraft engine starting is extracted directly from the compressor discharge scroll of the gas turbine engine through a flow-limiting venturi, which prevents engine overloading if the air supply duct breaks or is disconnected with the outlet valve open. Cooled air for flight deck conditioning is obtained by supplying compressor discharge air to a conventional aircraft refrigeration unit, consisting basically of an air-to-air heat exchanger and an expansion turbine driving a cooling air blower. The controls and instruments for the gas turbine engine and associated equipment, together with the electric voltage regulator and a protective panel, are situated at a convenient level at the rear of the cart.

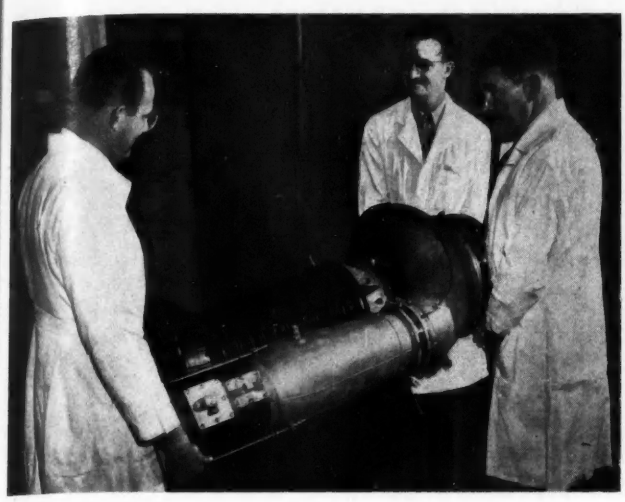
Differential Tin Plating

WITH the conventional method of hot-dip tin plating employed in the steel industry, the thickness of the tin coating is equal on each side of the base metal. In some cases this can be an unnecessary waste of tin. By differentially coating the tin material, a coating thick enough to protect the inside of a tin from attack may be deposited, while a much thinner one is plated on the exterior. This so-called "dual coating" is now being carried out on an acid-halogen electrolytic tinning line at the Aliquippa Works of the Jones and Laughlin Steel Corporation near Pittsburgh. For tins holding foods like tomatoes, tomato juice and peaches, the weight of the tin plate on one side of the base metal is equal to 1 lb per base box, while that on the other side is equal to 0·25 lb per base box. A base box, the unit by which tin plate is sold in the United States, has an area equal to 31,360 square inches. The company is now producing this kind of tin plate in quantity also for use in the fabrication of air cleaners, oil filters, and for other stamped automotive parts. For these applications the thickness of the tin plate is said to be in some cases about twice the thickness of what used to be considered the maximum that could be produced commercially.

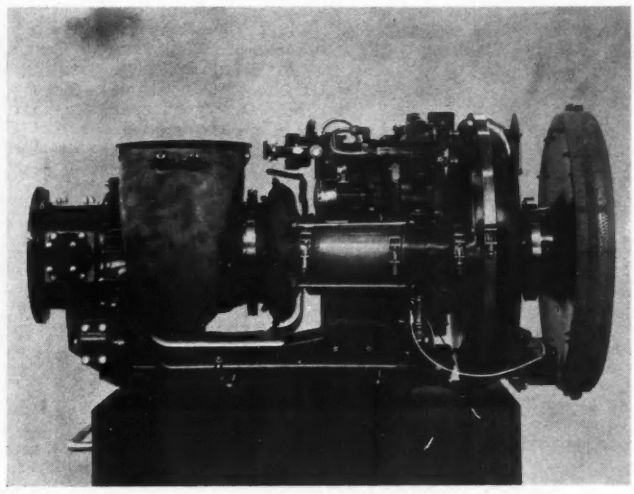
Nuclear Propulsion of Large Naval Vessels

LEWIS L. STRAUSS, the Chairman of the U.S. Atomic Energy Commission, and Charles E. Wilson, the U.S. Secretary of Defence, recently announced two projects for the development of nuclear propulsion of large naval vessels. Research and development work on a reactor suitable for large ship propulsion has been assigned to the Westinghouse Electric Corporation. Separate design studies of large nuclear-powered ships have recently been undertaken by the Newport News Shipbuilding and Dry Dock Company at Newport News, Virginia, and the Bethlehem Steel Company, at Quincy, Massachusetts, both under contract with the Bureau of Ships of the U.S. Navy. The pressurised water reactor design has been selected for this project and the reactor development work was assigned to the Westinghouse company because of its wide experience with this particular kind of reactor. The same company is at present developing the large-scale central station power reactor for the Duquesne Light Company at Shippingport, Pennsylvania, which was described in THE ENGINEER of October 1, 1954.

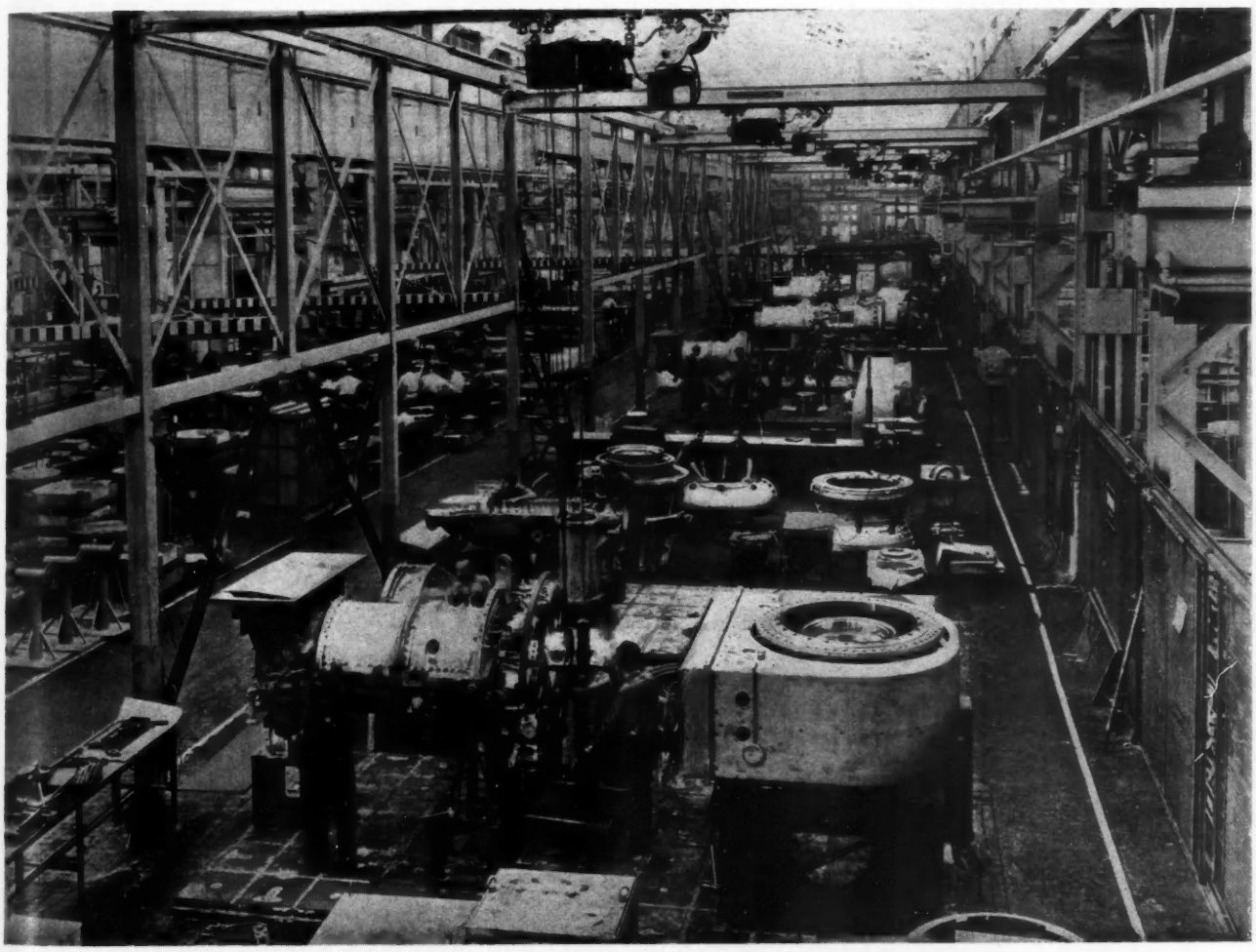
PRODUCTION OF GAS TURBINES IN THE UNITED STATES IN 1954



The light-weight model "T–520" "Jupiter" gas turbine engine of the Solar Aircraft Company, which is rated 500 h.p. at 20,000 r.p.m. at 75 deg. Fah. ambient temperature. The basic, dry weight of the unit is only 449 lb, and it occupies a space of 60in by 32in by 40in. The turbine operates on the simple, open cycle and employs a ten-stage axial-flow compressor and a single-can combustor

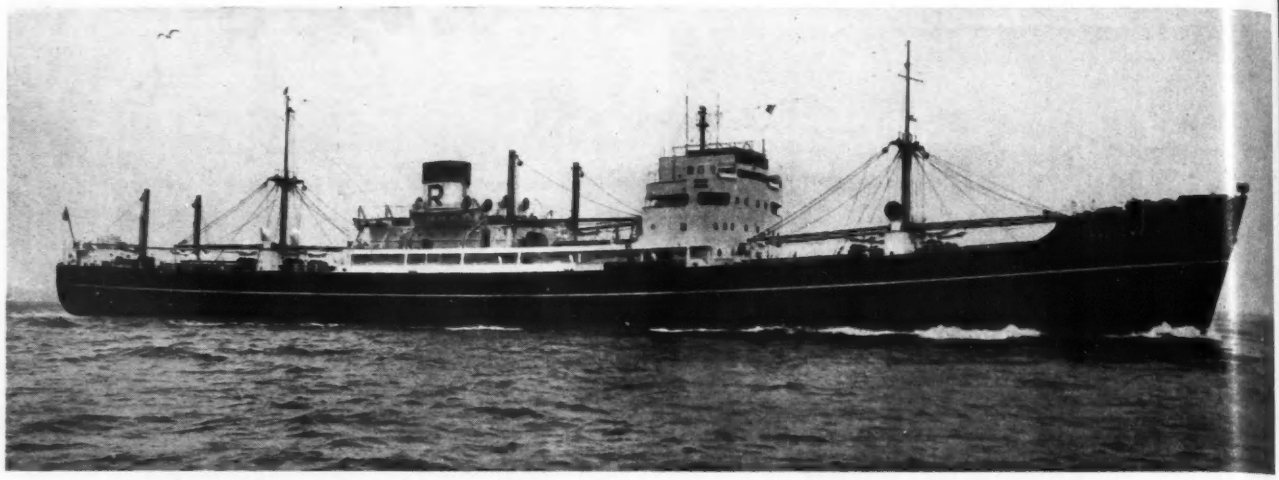


The model "502–10" gas turbine engine of the Boeing Airplane Company, which produces a maximum of 270 h.p. at 3100 r.p.m., weighs only 245 lb dry, and can operate without modification on a variety of fuels ranging from commercial diesel oil to petrol. The engine is a development of the company's earlier model "502–2," of which more than 300 units have been built for use as a prime mover in road vehicles, aircraft, boats, pumps, compressors and electric generators

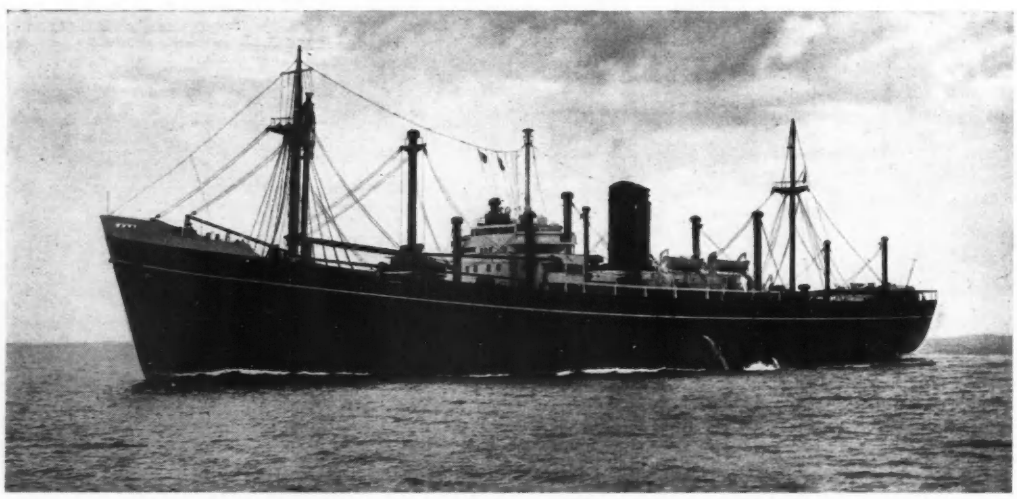


The gas turbine assembly area at the Schenectady Works of The General Electric Company indicates the considerable rate at which the relatively small gas turbines of the company are now being manufactured. The majority of these machines are of simple or regenerative open cycle design, of 5000kW rated capacity, and offering thermal efficiencies up to 28 per cent

CARGO SHIPS OF 1954

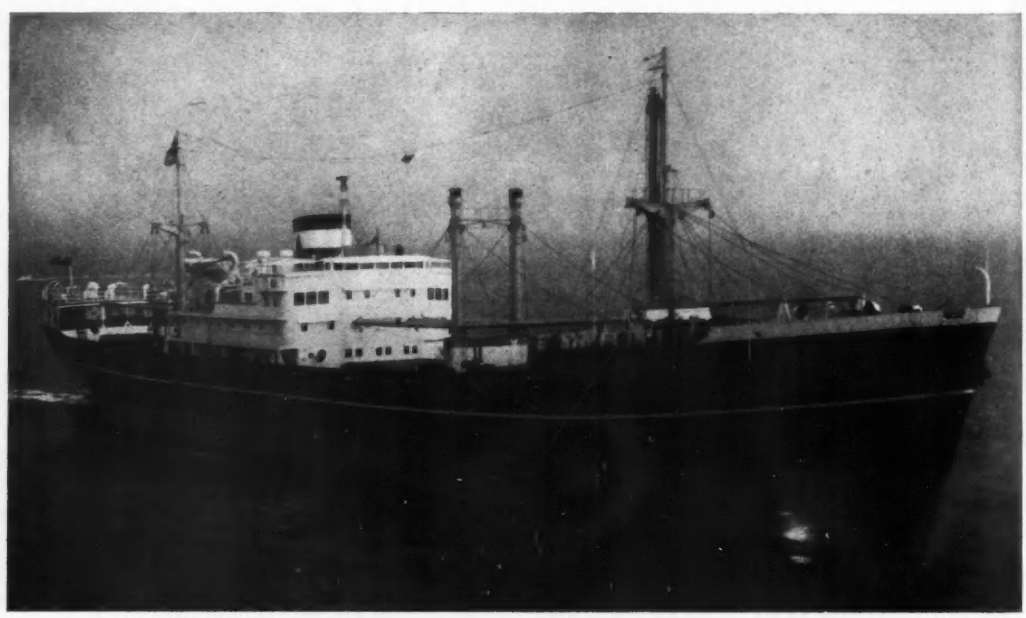


The M.V. "Hazelmoor" was constructed by Hawthorn Leslie (Shipbuilders), Ltd., to the order of the Moor Line, Ltd., and carries a deadweight of about 9540 tons at a service speed of 13 knots. There are five holds all arranged for the carriage of grain and the ship has the following dimensions:—Length between perpendiculars, 423ft; breadth moulded, 58ft; depth moulded to upper deck, 29ft, and draught 25ft 8½in. Two 40kW, steam-driven generators are installed and the ship is propelled by a four-cylinder Hawthorn-Doxford oil engine of 600mm bore and 2320mm combined stroke, and developing 3300 b.h.p. at 108 r.p.m.



The P. & O. Company's S.S. "Ballarat" built by Alexander Stephen and Sons, Ltd. There are six holds for general cargo with 5-ton and 10-ton derricks with the addition of an 80-ton derrick at No. 2 hatch. The main particulars are: length between perpendiculars 490ft, breadth moulded 69ft, depth to shelter deck 43ft, deep load draught 29ft 9in, deadweight approximately 12,790 tons and gross tonnage 9300. A single set of geared triple-expansion turbines which develop 11,000 s.h.p. in service and a maximum of 13,000 s.h.p. give the ship a service speed of 18 knots. Steam is supplied at 500 lb per square inch, 850 deg. Fah. by two Foster Wheeler boilers.

M.V. "Temple Hall." The single screw motor ship, "Temple Hall," was completed by The Caledon Shipbuilding and Engineering Company, Ltd., for the Temple Steamship Company, Ltd., and has a length between perpendiculars of 425ft, a breadth moulded 58ft 6in, a depth to shelter deck of 37ft 9in. A deadweight of 10,400 tons is carried on a draught of 26ft 11¼in and there are five holds served by one 30-ton and ten 10-ton derricks and the ship is equipped with electric deck machinery. The electrical power is provided by three 200kW diesel-driven generators and the ship is driven at a service speed of 12 knots by a Vickers-Doxford oil engine which develops 3300 b.h.p. at 108 r.p.m.



Industrial and Labour Notes

Railway Wage Dispute

On Thursday and Friday of last week, the Court of Inquiry appointed by the Minister of Labour to examine the railway wages dispute sat in public session to receive evidence. The case for the National Union of Railwaymen was submitted by Mr. J. Campbell, the union's general secretary, who claimed that after seventeen months of negotiations railway wages were still unreasonably low. He recalled the application in the latter part of 1953 for an all-round increase of 15 per cent on rates then existing, and said that the settlement reached on December 16, 1953, provided for revision of the wages structure. Since then, Mr. Campbell continued, there had been thirty-eight meetings with the British Transport Commission, but, he asserted, at an early stage in the negotiations it was evident that the Commission's conception of a new wages structure was far removed from that of the N.U.R. No solid progress could be made, Mr. Campbell added, in view of the Commission's repeated protestations that it had already exceeded the limit of its financial resources. Mr. Campbell went on to say that the N.U.R. executive had reluctantly reached a settlement with the Transport Commission in October last, but when the terms of that settlement, with their very modest increases, became known, there was widespread revolt and an immediate danger of unofficial stoppages all over the country. The recent award to locomotive men, estimated to cost £3,000,000 a year, made it inevitable, Mr. Campbell said, that the wage rates of other grades should be adjusted. The N.U.R. executive felt that as long as the British Transport Commission continued to plead inability to meet the higher wages it expressed the wish to pay, any new negotiations were doomed to failure. Mr. Campbell ended his statement by saying that if the financial obligations placed on the British Transport Commission prevented its paying reasonable wages, then "some other way must be found." The N.U.R., he claimed, had never suggested some annual subsidy, but it did suggest that the Commission should be relieved, for a few years at any rate, of some of the financial burden placed upon it by Parliament.

The British Transport Commission's case was then submitted to the Court by Mr. W. P. Allen, the member who deals with labour matters. He said that for the year 1954, it was expected that railway gross receipts of about £450,000,000 would meet working expenses and leave net receipts of about £18,000,000 before meeting central charges, which were likely to be of the order of £56,000,000. Accordingly, for 1954, it was anticipated that the railways would be in deficit to the extent of over £20,000,000 after account had been taken of proper contributions to central charges. Mr. Allen went on to say that the results for 1954 would not reflect fully the increase in working expenditure which had occurred during the year. In 1955, the railways would have to meet for a full year the wage increases granted in 1954, in addition to the cost of the new pension scheme and higher national insurance contributions. For the British Transport Commission as a whole, Mr. Allen added, the result for the year 1955 might be a deficit of £25,000,000. That, he pointed out, was a matter of great concern to the Commission and active measures were being taken to deal with the situation. First of all, Mr. Allen said, the Commission would continue to seek for all possible efficiency and economy in operation, in which direction the staff could render great assistance by stopping some of the restrictive practices. The Commission would also proceed with the curtailment of its more seriously unremunerative services. But such steps, Mr. Allen explained, would hardly be sufficient to put things right, and a big deficit was likely to remain which must be met somehow by the public, as the Commission had no reserves. If further increases in wages were now to be granted, the deficit would be correspondingly increased. Mr. Allen then went on to refer to the agreement made last October with the National Union of Railwaymen, saying that the Commission looked upon it as the final settlement of the 15 per cent claim put forward by the unions towards the end of 1953. That view had been made clear to the N.U.R. and although the agreement had never been signed, the rates stipulated in it were being paid. But the N.U.R. had repudiated the agreement, although it had been pressed by the Commission to dispose of the matter, and if it had any further submissions to put forward a new claim. Answering questions put by Sir John Cameron, Q.C., chairman of the Court, Mr. Allen said that the wage increases granted in December, 1953, and the cost of the pensions scheme would mean an additional charge of about £24,500,000 in a full year. He also said that the Commission was prepared to consider representations for a further wage increase, but what it was not prepared to do was to reopen discussion on the October agreement.

The Court of Inquiry presented an interim report to the Minister of Labour on Tuesday last, and on Wednesday the Minister had separate conversations with representatives of the National Union of Railwaymen and of the British Transport Commission. But as these notes go to press, no statement has been made about the outcome of these talks.

Railway Workers' Earnings

The British Transport Commission has recently published the results of its annual census of staff showing, among other matters, the average rates of pay and average earnings of the staff of British Railways in the week ended March 27, 1954. The figures, which are concerned with male adults, show that the average rate of pay of 47,797 clerical staff was £8 17s. 4d., the average earnings in the week of the census being £9 19s. 5d.; the technical staff numbered 3430, the average rate being £11 4s. 9d., and the average earnings £11 16s. 3d. Salaried station masters, yardmasters, goods agents, &c., numbered 5060, their average rate being £10 0s. 10d., and their average earnings £10 18s. 4d. In the conciliation grades, there were 39,015 locomotive drivers, whose average weekly rate was £8 17s. 2d., and average earnings £11 0s. 3d.; the 1774 motormen, whose average rate was £8 17s. 3d., showed average earnings of £10 11s. 2d., and for 36,553 firemen and assistant motormen, the average rate was £7 7s. 10d., the average earnings in the census week being £9 2s. 8d. Other figures included in the census relate to guards whose average rate was £7 6s. 8d., with average earnings of £9 8s. 3d.; signalmen, whose rate was £7 7s. 5d., and average earnings £9 13s. 7d., and porters whose average rate was £6 8s. and average earnings £7 18s. 6d. The average rate of pay is the basic payment laid down in the various agreements with the employees' representatives; the average earnings shown in the census cover the total payments for all work done in the week ended March 27th, 1954.

Changes in Wage Rates

The Ministry of Labour has stated that changes in wage rates which were reported as coming into operation in November resulted in an aggregate increase of approximately £345,000 in the weekly full-time wages of 874,000 workpeople, and a decrease of about £5100 for 176,000 workpeople. The decreases operated under sliding scale arrangements based on the index of retail prices, and mainly affected workers in the iron and steel industry, ironstone and limestone mining and quarrying in many districts.

Among those who received wage increases were the locomotive running staff of British Railways and operating staff employed in municipal tramway, trolleybus and omnibus undertakings. In the case of the locomotive men, the revised pay schedules adopted resulted in increases of up to 26s. a week according to grade and service. For the operating staffs of municipal passenger transport undertakings outside the London area, there were increases of 8s. a week for drivers and conductors, and of 7s., 6s. or 5s. according to grade for semi-skilled and unskilled workers in depots and garages.

The Ministry of Labour says that in the first eleven months of 1954, changes in wage rates led to an aggregate increase estimated at £3,369,000 in the weekly full-time wages of 9,934,500 workpeople. In the comparable period of 1953, there was a net increase of £2,246,000 in the weekly full-time wages of 8,215,000 workpeople. At the end of November last, the index of rates of wages (June 30, 1947 =100) stood at 144 for all workers, a rise of one point since the end of August.

Trade Disputes

Figures published in the *Ministry of Labour Gazette* show that, during November, 179 stoppages of work through disputes were reported, and that nineteen stoppages of work which had begun prior to November were still in progress in the early part of that month. In these 198 stoppages, 48,500 workers were involved during November, with the result that 304,000 working days were lost. Most of the stoppages occurred in the coal mining industry, where it is estimated that 50,000 working days were lost.

The Ministry of Labour states that eleven of the stoppages of work in November arose over demands for wage increases and that sixty-three were concerned with other wage questions. There were seven stoppages through disputes over working hours; nineteen over questions respecting the employment of particular classes or persons; seventy-seven stoppages on other questions about working arrangements, and two stoppages over questions of trade union principle.

In the eleven months January to November, 1954, there were 1844 stoppages of work through disputes. The number of workpeople involved was 415,100, and it is estimated that 2,389,000 working days were lost. In the corresponding period of 1953, there were 1626 stoppages involving 275,000 workpeople and causing an aggregate loss of 1,050,000 working days.

Coal Production

The Ministry of Fuel and Power has issued a preliminary statement about coal production in Great Britain in 1954. It shows that in the fifty-two weeks ended last Saturday, deep-mined output amounted to 213,551,200 tons, and that the output from opencast workings was 10,243,900 tons, making a total of 223,795,100 tons. In 1953, the output from the deep mines was 211,820,900 tons, and from opencast workings 11,698,100 tons, making a total of 223,519,000 tons. Last year's deep-mined output was thus only 1,730,300 tons above the 1953 figure, and fell considerably below the additional quantity hoped for earlier by the National Coal Board and the National Union of Mineworkers. Last year's opencast production was about 1,450,000 tons below the amount achieved in 1953, part of the deficit, no doubt, being attributable to the bad weather during many weeks of the summer. In the last two weeks of 1954, which included the Christmas holiday, deep-mined coal output amounted to 6,264,600 tons and opencast output to 182,400 tons, making a total of 6,447,000 tons. In the final two weeks of 1953, total coal output was 6,611,500 tons.

Index of Industrial Production

The Treasury has reported that the index number of industrial production (1948=100), which is prepared by its central statistical office, has been estimated provisionally at 135 for all industries in October, 1954, compared with a revised figure of 131 for September. Figures for the corresponding months of 1953 were 131 in October and 125 in September. Taking the manufacturing industries only, the index in October last was 140, compared with 135 a year earlier, and for mining and quarrying it was 118, compared with 116 in October, 1953. The Treasury says that, according to information it has already received, the index for all industries in November last is likely to be 136 or 137. In November, 1953, it was 133.

Personal and Business

Appointments

SIMON-CARVES, Ltd. (power plant department), states that Mr. J. D. Knox has been appointed to take charge of its London office at Simon House, 6, Stratton Street, W.1.

MR. F. R. JOLLEY and Mr. J. R. ROWLANDS have been appointed joint managing directors of Simon Handling Engineers, Ltd., Cheadle Heath, Stockport. Mr. I. Hey continues as chairman of the company.

MR. H. R. COX, M.I.Loco.E., has been appointed general assistant to the motive power superintendent at Swindon, in the Western Region of British Railways. He was formerly assistant district motive power superintendent at Newport.

THE BRITISH TRANSPORT COMMISSION announces the appointment of Sir H. Reginald Kerr, K.B.E., as general manager, British Transport Waterways. Since September, 1948, Sir Reginald has been manager of the Midland Division of British Road Services.

MR. H. J. HAON has been appointed manager of the European office of E. I. du Pont de Nemours and Co., at Bush House, Aldwych, London, W.C.2. He succeeds Mr. S. R. Stager, who is returning to the U.S.A. to take up an appointment at the company's headquarters.

MESSRS. KENNEDY AND DONKIN, 12, Caxton Street, London, S.W.1, state that the following senior members of their staff have been appointed consultants :—Mr. J. North, M.I.C.E., Mr. M. V. Ratcliffe, M.I.E.E., and Mr. F. J. Hutchinson, M.I.Mech.E., M.I.E.E.

MR. G. WATSON-WILLIAMS has accepted an appointment from the United Nations Technical Assistance Administration to serve as industrial economist to the Government of Indonesia. The appointment, which is for one year, has been made at the request of the Indonesian Government.

ROLLS-ROYCE, Ltd., Derby, announces the appointment of Mr. F. Nixon, M.I.Mech.E., as chief quality engineer of its aero-division, in succession to Mr. E. J. Cantrill, who has retired. Mr. Nixon joined the staff of Rolls-Royce, Ltd., in 1942, prior to which he was design manager in the engine department of the Bristol Aeroplane Company, Ltd.

THE NATIONAL GAS BOARD has asked Sir William McGilvray to continue as director-general of marketing for a further period. He will deal principally with questions of policy. Mr. J. Norval has been appointed to the Board's marketing headquarters in London to assist Mr. R. H. Thomas and Mr. R. J. Moffat, who will continue to act as deputy director-general of marketing.

MR. B. G. H. ROWLEY, A.M.I.E.E., has been appointed manager of the maritime division of Marconi's Wireless Telegraph Company, Ltd. Since 1950, he has been the company's technical representative in the U.S.A. Mr. Rowley succeeds Mr. G. R. Tyler, who, having reached normal retiring age, has relinquished his position in the maritime division. Mr. Tyler is continuing in the service of the Marconi Company as representative in West Africa.

WOODALL-DUCKHAM CONSTRUCTION COMPANY, Ltd., 63–77, Brompton Road, London, S.W.3, announces the appointment of Mr. J. Simpson as joint managing director in succession to Mr. J. S. Jeffrey. Mr. Simpson joined the company in 1926 and was appointed to the board in 1946. Mr. Jeffrey, who has now retired, joined the company's staff in 1912 and has been joint managing director since 1948. He will continue to serve on the board of Woodall-Duckham, Ltd., the parent company.

Business Announcements

SMITHS INDUSTRIAL INSTRUMENTS, Ltd., states that its address is now 123–145, North Street, Glasgow, C.3 (telephone, Glasgow Central 3972).

LE TOURNEAU-WESTINGHOUSE COMPANY, Peoria, Illinois, has purchased the plant and assets of the J. D. Adams Manufacturing Company, Indianapolis, Indiana.

IRA STEPHENS, Ltd., and STEPHENS BELTING COMPANY, Ltd., have formed a new company entitled Stephens Miraclo Belts, Ltd., for the production and distribution of " Miraclo " nylon belting.

VAUXHALL MOTORS, Ltd., Luton, has announced the retirement of Sir Charles Bartlett from the board. Sir Charles has been managing director of the company for twenty-three years and chairman since June, 1953.

MR. H. W. BARNETT has relinquished his position as London manager of The Butterley Company, Ltd., and has started an engineering advertising service at Room 15, Clarence House, Arthur Street, London, E.C.4.

ALBRIGHT AND WILSON, Ltd., states that the ownership of its silicone manufacturing plant at Barry, South Wales, has been transferred to Midland Silicones, Ltd., in which company Albright and Wilson, Ltd., is the majority shareholder.

BRITISH INDUSTRIAL PLASTICS, Ltd., Popes Lane, Oldbury, Birmingham, announces the formation of a wholly-owned subsidiary, entitled B.I.P. Chemicals, Ltd., for the manufacture and sale of moulding powders, synthetic resins and other plastics raw materials.

HEAD, WRIGHTSON AND CO., Ltd., Thornaby-on-Tees, has acquired the whole share capital of F. P. Caird and Co., Ltd., 19, Waterloo Street, Glasgow. The name of the company is being changed to Head Wrightson (Scotland), Ltd., and Mr. J. T. Young will take charge of the Glasgow office.

DAVIES AND METCALFE, Ltd., of Romiley, has secured the manufacturing rights for this country and the British Commonwealth of a new and improved air brake system for locomotives. This system has been developed by the Oerlikon Machine Tool Works, of Zurich, and is now in use on a number of Continental railways.

DUNLOP, Ltd., has announced the retirement of Mr. Frederick Walker, M.I.Mech.E., from the position of chief engineer at Fort Dunlop. Mr. Walker, who succeeded to the position of chief engineer in 1943, joined the Dunlop organisation in 1914. He is chairman of the Midland branch of the Institution of Mechanical Engineers.

WICKMAN, Ltd., announces that its induction heating equipment business has been acquired by Wild-Barfield Electric Furnaces, Ltd. Manufacture of induction heating generators and fixtures will continue for the present at the works of Wickman, Ltd., Oxgate Lane, Cricklewood, London, N.W.2, and is to be transferred later to the works of Wild-Barfield Electric Furnaces, Ltd., Watford, Herts. Mr. F. L. Gladwin has become sales manager of the latter firm's induction heating department.

Miscellanea

BUSINESS EFFICIENCY EXHIBITION.—The first of the regional exhibitions to be organised in 1955 by the Office Appliance and Business Equipment Trades Association is to be held at the Granby Hall, Leicester, from February 8th to 11th.

OBITUARY.—We record with regret the death of Mr. W. Mills, a director and former secretary of Brook Motors, Ltd., Huddersfield, which occurred on Christmas Day, at the age of sixty-six. We have also learned with regret of the death of Mr. V. W. Green, manager of the Gloucester branch of British Insulated Callender's Cables, Ltd.

BOLTON TECHNICAL TEACHERS' COLLEGE.—A question was addressed recently in Parliament to the Minister of Education about the future of the Bolton Technical Teachers' Training College. The Minister said, in reply, that after careful consideration he had concluded that the college should continue and that the necessary capital development should proceed.

ASLIB AERONAUTICAL CONFERENCE.—The Fourth Annual Conference of the Aslib Aeronautical Group will be held at Cranfield, from Friday, April 1, to Sunday, April 3, 1955. The main discussion will centre on Classification, and the Classification Research Group will co-operate in the conference. Full particulars may be obtained from Mr. C. W. Cleverdon, Librarian, College of Aeronautics, Cranfield, Bletchley, Bucks.

NATIONAL POWER FARMING CONFERENCE.—The fifth National Power Farming Conference is to be held at Harrogate from February 15th to 17th, inclusive, under the chairmanship of Mr. J. T. Berresford. The papers to be discussed will cover many aspects of agricultural machinery utilisation, though the emphasis will be on mechanical handling. On Friday, February 18th, the conference delegates will visit the Doncaster works of International Harvester Company of Great Britain, Ltd.

TRANSPORT COMMISSION'S AREA BOARDS.—The British Transport Commission has now announced the membership of the six area boards which it has set up by virtue of the British Transport Commission (Organisation) Scheme Order, 1954. The boards begin the functions delegated to them by this order on February 1st. The chairmen of the boards are Sir Ian Bolton, Bt. (Scottish area), Mr. T. H. Summerson (N.E. area), Sir Reginald Wilson (Eastern area), Sir Philip Warter (Southern area), Sir Herbert Merrett (Western area), and Lord Rusholme (London Midland area).

LARGE COMMERCIAL TYRE.—An abnormally large tyre, the " Highway," has been introduced by the Dunlop Rubber Company, Ltd., for commercial vehicles on normal road surfaces. It has a flatter tread with new rib design details. A deeper tread pattern is claimed to give higher in-built mileage, and extra width and new groove design to give greater traction, while the flatter tread and continuous shoulder ribs are expected to result in slower and more even wear. There are reinforced buttressed shoulders to resist kerb and road damage, and new bead and clinch construction for greater stability and resistance to rim chafing.

STUDY OF FARM IMPLEMENT PRODUCTION.—The United States Department of Labor has recently prepared, for the Foreign Operations Administration, a report on the factory production of farm implements. It is one of a series of repute examining productivity and factory performance. The present report, like the others in the series, is intended primarily for the use of European production managers and methods engineers who are concerned with productivity problems. The report, which deals principally with the production of ploughs, harrows and mowers in American plants, can be obtained in this country from the British Institute of Management, 8, Hill Street, London, W.1, price 10s.

RESIDENTIAL COURSES ON BOILER-HOUSE PRACTICE.—Residential courses on boiler-house practice are being conducted at the Royal Naval Barracks, Portsmouth, under arrangements made by the Admiralty and the National Industrial Fuel Efficiency Service. It is stated that a limited number of students from industry can be accommodated. Although the courses are designed primarily for naval personnel leaving the Service, they are suitable for industrial boiler-house staff who may be unable, on account of shift work or other reasons, to attend a part-time course at a technical college. The overall fee for a four-week course, which includes accommodation and meals, is £25. The next course begins on January 31st. Further details can be obtained from the National Industrial Fuel Efficiency Service, 71, Grosvenor Street, London, W.1.

SAUGUS IRONWORKS RESTORATION.—The restoration of the seventeenth century Hammersmith iron works, at Saugus, Massachusetts, has recently been completed. From these works, it is stated, America's iron and steel industry sprang. The works were originally planned by John Winthrop, son of the first Governor of Massachusetts Bay Colony, and were financed principally by British investors, with assistance from Saugus residents, their organisation being entitled " Company of Undertakers for the Iron Works in New England." The works comprised a blast-furnace, forge, a rolling and slitting mill, a wharf, a warehouse and the ironmaster's house. It is reported that all these have been authentically reproduced in the restoration, the work having been undertaken by the American Iron and Steel Institute, in co-operation with Massachusetts residents and the First Ironworks Association.

LOCOMOTIVES FOR SOUTH AMERICA.—Particulars have been received from the Yorkshire Engine Company, Ltd., of Sheffield, of two 2–8–2 oil-burning, mixed-traffic locomotives recently completed for the Chilean Northern Railway. These locomotives are generally similar to others supplied to the railway in 1928 and their leading dimensions are as follows :—Cylinders (two), 19in by 24in ; wheels, coupled, 3ft 8in diameter ; wheels (trucks), 2ft 4in diameter ; coupled wheel base, 11ft 9in ; total evaporative heating surface, 1694 square feet ; superheater, 366 square feet ; grate area, 29·7 square feet. In the original locomotives the boiler was designed for a steam pressure of 180 lb per square inch, although the working steam pressure was only 150 lb per square inch. With this the tractive effort at 85 per cent pressure was 25,050 lb for an adhesive weight of 44 tons. In the new locomotives the working pressure has been increased to 160 lb per square inch so that the tractive effort is now 26,780 lb, for which the adhesive weight has been increased to 46 tons. The increase in axle load from 11 to 11¼ tons on the coupled wheels only has been obtained by thickening the bar frame, frame stretchers and boiler plates. The spring suspension, which is overhung, has also been modified from two to three groups to avoid excessive disturbance of weight distribution in the event of a failure of a suspension link or compensating beam.

Launches and Trial Trips

POLARPRINS, oil tanker ; built by Barclay Curle and Co., Ltd., for Hvalfangerselskapet Polaris A/S, Norway ; length 557ft, breadth 73ft 9in, depth 40ft, deadweight 18,300 tons ; twenty-seven cargo oil tanks, two pump rooms, four cargo oil pumps ; Barclay Curle-Doxford oil engine, six cylinders, 750mm diameter by 2500mm combined stroke, Doxford-Bibby detuner, two cylindrical multi-tubular boilers. Launch, December 10th.

FERNVALLEY, cargo liner ; built by Alexander Stephen and Sons, Ltd., for Det Bergenske Dampskipsselskab ; length 400ft., breadth 57ft, depth 35ft, deadweight 6530 tons, load draught 23ft ; twelve passengers ; five holds, electric deck machinery, derrick complement includes one to lift 30 tons; three 180kW diesel-driven generators ; Stephen-Doxford two-cycle oil engine, four cylinders 670mm diameter by 2330mm combined stroke. Launch, December 14th.

ARAFURA, cargo liner ; built by Barclay, Curle and Co., Ltd., for the Eastern and Australian Steamship Company, Ltd.; length 482ft, breadth 63ft, depth to upper deck 39ft, deadweight 10,800 tons, gross tonnage 9300 ; five cargo holds ; eight 5-ton, eight 10-ton, one 20-ton and one 35-ton derricks, electrical deck machinery; four 300kW diesel-driven generators; one set of three casing geared turbines, service power developed at 101 r.p.m. of the propeller, steam supplied at 450 lb per square inch and 750 deg. Fah. by two water-tube boilers. Trial, December 14th.

BORDER MINSTREL, oil tanker ; built by Blythswood Shipbuilding Company, Ltd., for the Lowland Tanker Company, Ltd.; length between perpendiculars 515ft, breadth moulded 69ft 6in, depth moulded 37ft 6in, deadweight 16,150 tons ; twenty-seven cargo oil tanks, two cargo pump rooms, four 500 tons per hour cargo oil pumps, trial speed 15½ knots ; Rowan-Doxford two-stroke, oil engine, six cylinders, 670mm diameter by 2320mm combined stroke, 6800 b.h.p., two oil-fired Scotch boilers. Trial, December 16th.

British Patent Specifications

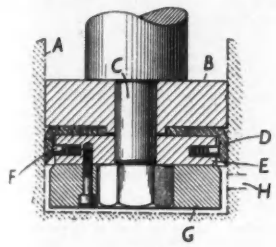
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

HYDRAULIC MACHINERY

719,389. September 10, 1951.—Sealing and Damping Devices for Pistons, Qualcraft General Engineering Products, Ltd., and Ernest Edward Churchouse and Evan Brynly Williams, all of North View, Caerphilly, Glamorgan.

The invention relates to a device in which a piston is displaced in a cylinder by fluid under pressure. The object of the invention is to provide the piston with improved sealing and damping means for bringing it quietly to rest on its return stroke. In the drawing the hydraulic piston head is shown near the bottom of its stroke in a cylinder *A*. The piston head comprises an annular back plate *B*, which fits around



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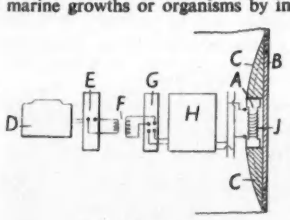
the reduced end of a piston rod *C*, and the cup-shaped washer *D* is clamped against the back plate by a disc *E* and nut. The disc *E*, which is enclosed by the skirt of the washer, has around its periphery a series of equally spaced and radially directed recesses, in each of which a spring-loaded plunger *F* is slidably mounted. The plungers project slightly and bear against the inside of the skirt of the washer to maintain a seal between the piston and cylinder. In order that the return stroke of the piston may take place silently, a block *G* providing a damper action, is, secured to the outer face of the disc *E*. The block, which may be of cast iron, has a diameter slightly less than that of the cylinder. On the return stroke of the piston the hydraulic fluid is forced during the last stage of travel around the space between the block *G* and the wall of the cylinder, and thence through an outlet port *H*. The flow of displaced fluid during the return stroke of the piston is slightly restricted and this ensures that the piston head and the parts which move with it come silently to rest.—*December* 1, 1954.

MARINE ENGINEERING

719,650. March 15, 1952.—The Fouling of Ships' Hulls, Postans, Ltd., Trevor Street Works, Birmingham, 7; and Michael Henry Miller Arnold, 224, Chester Road North, Sutton Coldfield; and David Blythe Foster, 16, Mount Park Road, Ealing, London, W.5.

The invention has reference to an improved method of preventing or minimising the fouling of ships' hulls by marine growths or organisms by imparting



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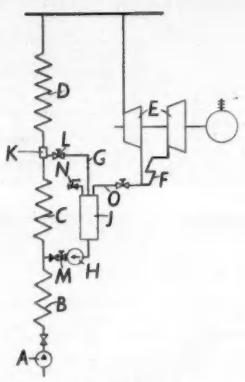
molecular vibration at ultrasonic frequencies of the material of which the hull is constructed. As illustrated in the drawing, the core *A* of the transducer is arranged horizontally and parallel to the inner surface of the ship's hull *B* and at each end the core abuts with humps *C* rigidly fixed to the hull. The transducer forms part of an installation incorporating a prime mover *D*, such as a steam turbine, an alternator *E* which generates electric current at 230V and is driven by the prime mover, a step-up transformer *F*, for transforming the current, a rectifier *G* for rectifying the current from the secondary of the transformer *F*, and an oscillator *H* for generating alternating electric current at frequencies in the ultrasonic range, and for supplying these currents to the winding *J* of the transducer. If desired, more than one transducer may be used and the transducer or each transducer may be surrounded by a casing through which is circulated a liquid coolant. Different methods of attaching the transducer to the surface of the hull are described in the specification.—*December* 8, 1954.

STEAM GENERATORS

719,753. October 1, 1952.—Forced Through-Flow Boilers, Siemens-Schuckertwerke Aktiengesellschaft, Berlin and Erlangen, Germany.

The invention relates to forced through-flow boilers and provides a method and a boiler whereby it is possible, with comparatively simple means, to start with a load range down to about 10 per cent of the normal load and in certain cases even less. The drawing shows a construction of a forced through-flow boiler with the feed pump *A*, the preheater *B*, the vaporisation section *C*, and the superheater *D*. *E* is the turbine and the steam reheater is *F*. An arrangement for operating at minimum load comprises the by-pass pipe *G* for the endangered vaporiser section *C*



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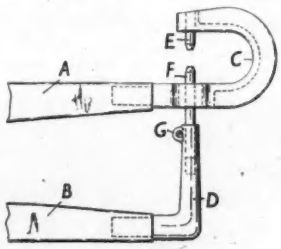
and the circulation pump *H*. As a result of this shunt to the part or section *C* it is always ensured that a sufficiently large quantity of water is circulating even at minimum load operation. It is, however, expedient to connect a drum or collecting container *J* in this pipe in order to have a certain buffering possibility in the event of any fluctuations. The pipe *G* is not connected directly to the tube system of the forced through-flow boiler, but to a separator *K* in which steam and water are separated. *L* is a shut-off valve and *M* a similar valve on the return flow pipe. *N* is the safety valve. For the purpose of producing a sufficiently large pressure drop between the separator *K* and the container *J* there is provided the pipe *O*, which connects the container *J* with the intermediate steam reheater *F* and thus with a stage of correspondingly lower pressure.—*December* 8, 1954.

WELDING

719,890. July 24, 1952.—Portable Electric Welding Devices, William Lowton, 250, Mays Lane, Barnet, Hertfordshire; and Meritus (Barnet), Ltd., 36, Wood Street, Barnet, Hertfordshire.

The invention consists in a portable electric welding tool having relatively movable levers carrying electrodes which, by manipulation of the levers, are moved together to grip a workpiece during a welding



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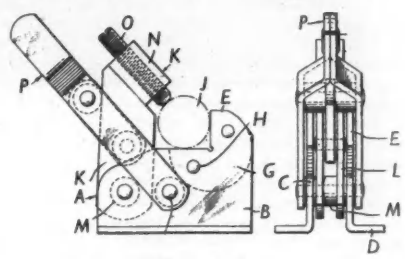
operation. As shown in the drawing, a portable electric welding tool comprises two U-sectioned or tubular metal levers *A* and *B*. One electrode holder may be in the form of a substantially semi-circular hook *C* at the forward end of one of the tong levers *A*, the hook lying in the plane in which the tong levers pivot in relation to one another, and turning outwards from its lever, i.e. away from the other tong lever *B*. The other electrode holder *D* is of L shape with its free limb projecting towards the electrode holder *C*. The hooked electrode holder at its free end has a tapered conical aperture, in which can be fitted a short copper rod electrode *E*. The L-shaped holder *D* has an aperture to receive a copper rod electrode *F* and at its extremity may be longitudinally slotted and provided with lugs *G*, drawn together by a screw to grip the electrode *F*. When fitted in their holders the electrodes are axially in line with one another and in order that their tips may meet the inner limb of the hooked holder *C* is enlarged and provided with an aperture through which the electrode of the L-shaped holder extends. It will be seen that the axis of the electrodes is substantially transverse of the tong levers so that the electrode tips can be moved together by the normal pivotal movement of the tong levers, but so that the tips engage one another at a point well to one side of the tong levers where the tool gives little obstruction to bringing the electrodes to a workpiece awkwardly positioned.—*December* 8, 1954.

TOOLS AND WORKSHOP APPLIANCES

719,634. November 7, 1951.—Clamps, Speed Tools, Ltd., Vereker Buildings, Gresse Street, London, W.1. (*Inventor: Kenneth Slade.*)

This invention relates to clamps operated by a toggle mechanism. As shown in the drawing, the clamp *A* includes a support member *B* comprising a pair of spaced vertical metal plates *C*. The plates have a supporting base in the form of a pair of flanges *D*. The upper edges of the plates are each formed with an upstanding portion *E* at their rear, the upstanding portions forming with the upper edge of



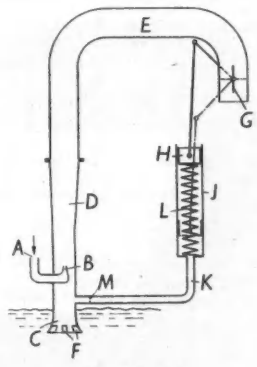
No. 719,634

the plates a fixed supporting jaw. The fixed jaw further includes a shaped member *G* of hardened steel rigidly secured between the plates by rivets. The hardened steel member is located with its operative surfaces level with the edges of the plates of the jaw and thus provides a firm support for a workpiece *J*. A second jaw member, shown generally at *K*, is mounted between the plates *C* and comprises a pair of plates *L* pivotally attached to the support member *B* and spaced apart by means of a distance piece *M*. The upper end of the plates *L* are welded together and carry a tubular member *N* forming the second and movable jaw of the clamp. The tubular member is internally threaded to receive a screwed member *O*. The jaw member is movable about its pivot pin to hold the workpiece *J* against the fixed jaw member and the arrangement gives in effect a firm three-point contact on the workpiece. The mechanism for moving the jaw *K* comprises an operating lever *P* formed by two levers jointed at one end to provide a handle and spaced at their other ends.—*December* 8, 1954.

PUMPS

719,492. May 1, 1952.—Jet Pumps for Delivering Liquids Mixed with Solid Substances, Maschinenfabrik Augsburg-Nurnberg A.G., Nurnberg 24, Germany.

The drawing shows an example of the invention. *A* is an inlet of the driving water. The driving jet which comes from a driving nozzle *B* breaks up the



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liquid or the delivery current mixed with the solid substances, which liquid enters through an inlet *C*. The driving current and the delivery current are mixed together in a combining nozzle *D* and are delivered through a pipe *E*. The free passage at the

inlet *F* is smaller than at any other point of the jet pump, so that stoppages, if any, can be expected only in the inlet. At the end of the pipe *E* there is a throttle flap valve *G*, driven by a piston *H* through a sliding crank. The lower surface of the piston working in a cylinder *J* is subjected through an impulse pipe *K* to the reduced pressure that arises in the inlet during normal operation. The piston is supported on its lower surface by a spring *L*. During the normal delivery of the jet pump the spring presses the piston upwards so that the throttle valve *G* is fully opened. If the inlet *C* is stopped up by the solid substances the pressure in the impulse pipe *K* falls so far below atmospheric pressure that the piston *H* is moved downwards by atmospheric pressure against the force of the spring and closes the throttle valve *G*. As a result of this the driving liquid entering the combining nozzle *D* is compelled to flow through the inlet *C* and wash away the solid substances. When the inlet is free the pressure in the pipe *K* again rises so that the piston moves upwards and opens the flap valve so that the delivery is again started. In the impulse pipe there is also provided a throttle disc *M* which damps the movements of the piston.—*December* 1, 1954.

Calendars and Diaries

We acknowledge receipt of calendars and/or diaries for 1955 from the undermentioned firms :

Wimpey, Hammersmith, London, W.6.

Swedish-Lloyd, Gothenburg, Sweden.

High Duty Alloys, Ltd., Slough, Bucks.

Ruston-Bucyrus, Ltd., Lincoln, England.

K.L.M. Royal Dutch Airlines, Holland.

Butters Brothers and Co., Ltd., London.

Thos. Storey (Engineers), Ltd., Stockport.

Holman Brothers, Ltd., Camborne, England.

Brook Motors, Ltd., Huddersfield, England.

B. Thornton, Ltd., Turnbridge, Huddersfield.

S. A. Brown Boveri, Baden, Switzerland.

The Tata Oil Mills Company, Ltd., Bombay.

J. E. Raistrick, Ltd., Colnbrook, Slough, Bucks.

Priest Furnaces, Ltd., Middlesbrough, England.

Aveling-Barford, Ltd., Invicta Works, Grantham.

Diemer and Reynolds, Ltd., Eastcotts Road, Bedford.

The Gas Council, 1, Grosvenor Place, London, S.W.1.

A.C.V. Sales, Ltd., 49, Berkeley Square, London, W.1.

Hunslet Engine Company, Ltd., Jack Lane, Leeds, 10.

Tube Investments, Ltd., Aston Manor, Birmingham, 6.

The D.P. Battery Company, Ltd., Bakewell, Derbyshire.

Richard Sutcliffe, Ltd., Horbury, Wakefield, Yorkshire.

The Gear Grinding Company, Ltd., Shirley, Birmingham.

Bakelite, Ltd., 12–18, Grosvenor Gardens, London, S.W.1.

Widnes Foundry and Engineering Company, Ltd., Widnes, Lancs.

Hall Harding, Ltd., Stourton House, Dacre Street, London, S.W.1.

Edward Wood and Co., Ltd., 68, Victoria Street, London, S.W.1.

Monsanto Chemicals, Ltd., Victoria Station House, London, S.W.1.

C. A. Parsons and Co., Ltd., Heaton Works, Newcastle upon Tyne, 6.

Joshua Bigwood and Son, Ltd., Wednesfield Road, Wolverhampton.

Atlas Diesel Company, Ltd., Beresford Avenue, Wembley, Middlesex.

Davidson and Co., Ltd., Sirocco Engineering Works, Belfast, N. Ireland.

Taylor Woodrow Construction, Ltd., 10, Park Street, London, W.1.

Bell's Asbestos and Engineering, Ltd., Bestobell Works, Slough, Bucks.

Stewarts and Lloyds, Ltd., 8, Gough Square, Fleet Street, London, E.C.4.

Industrial Waste Eliminators, Ltd., 7–11, Old Bailey, London, E.C.4.

Association of Building Technicians, 5, Ashley Place, London, S.W.1.

Edward G. Herbert, Ltd., Atlas Works, Levenshulme, Manchester, 19.

F. J. Edwards, Ltd., Edwards House, 359–361, Euston Road, London, N.W.1.

Fischer Bearing Company, Ltd., Upper Villiers Street, Wolverhampton.

British Vacuum Cleaner and Engineering Company, Ltd., Leatherhead, Surrey.

The Northern Manufacturing Company, Ltd., Albion Works, Gainsborough.

North British Locomotive Company, Ltd., 82, Victoria Street, London, S.W.1.

Spottiswoode, Ballantyne and Co., Ltd., 1, New Street Square, London, E.C.4.

Turner Brothers (B'ham), Ltd., Galvanic Works, Cleveland Street, Birmingham, 19.

Colton Electrical Equipment Company, Moor Lane, Cranham, Upminster, Essex.

The Anderson-Grice Company, Ltd., Taymouth Engineering Works, Carnoustie, Scotland.

Watson Manasty and Co., Ltd., 139, Richmond Road, Kingston-on-Thames, Surrey.

International Harvester Company of Great Britain, Ltd., Harvester House, 259, City Road, London, E.C.1.

Office of the High Commissioner for the Union of South Africa, South Africa House, Trafalgar Square, London, W.C.2.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

BELFAST ASSOCIATION OF ENGINEERS

Wed., Jan. 12th.—College of Technology, Belfast, "The Evolution of Mechanical Power Farming," John Chambers, 7.30 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., Jan. 12th.—N.E. Section : Neville Hall, Westgate Road, Newcastle upon Tyne, Address by the President, Rear-Admiral (L.) Sir Philip Clarke, 6 p.m.——W. Midlands Section : Technical College, Wulfruna Street, Wolverhampton, "Electronics in Materials Handling," L. Landon Goodman, 7.15 p.m.——S. Wales Section : Glamorgan Technical College, Treforest, "Electronic Counting Devices," F. H. Gage, 6.30 p.m.

Thurs., Jan. 13th.—Scottish Section : Institution of Engineers and Shipbuilders, Elmbank Crescent, Glasgow, Discussion on Channel III Commercial Television, 7 p.m.

CHEMICAL SOCIETY

Thurs., Jan. 13th.—Aberdeen Branch : Robert Gordon's Technical College, Aberdeen, "Application of Science in the Detection of Crime," J. B. Firth, 7.30 p.m.——Edinburgh Branch : North British Station Hotel, Edinburgh, "Organic Inclusion Compounds," W. Baker, 7.30 p.m.——Manchester Branch : The University, Manchester, "Colouring Matters of the Aphididae," Sir Alexander Todd, 6.30 p.m.

Fri., Jan. 14th.—Birmingham Branch : The University, Birmingham, "The Structures of Electron-Deficient Substances," H. C. Longuet-Higgins, 4.30 p.m.——Southampton Branch : The University, Southampton, "Fission Products," P. E. Carter, 7 p.m.

HULL CHEMICAL AND ENGINEERING SOCIETY

Tues., Jan. 11th.—Church Institute, Hull, Presidential Address, "Some Uses of Solvents," J. B. Moller, 7.30 p.m.

Thurs., Jan. 13th.—Imperial Hotel, Hull, "The Chemistry of Rockets," Dr. Hutchinson, 7 p.m.

ILLUMINATING ENGINEERING SOCIETY

To-day, Jan. 7th.—Bath and Bristol Centre : Royal Hotel, Bristol, "Studies in Interior Lighting," J. M. Waldram, 6.15 p.m.

Tues., Jan. 11th.—London Centre : Royal Society of Arts, John Adam Street, London, W.C.2, "Fading and Related Effects Associated with the Radiation from Light Sources," B. S. Cooper, 6 p.m.

INCORPORATED PLANT ENGINEERS

To-day, Jan. 7th.—Birmingham Branch : Imperial Hotel, Temple Street, Birmingham, "Gas Turbines in Industry," J. R. Needham, 7.30 p.m.

Mon., Jan. 10th.—Dundee Branch : Mathers Hotel, Dundee, "Fans and Fan Engineering," C. J. Atkins, 7.30 p.m.

Tues., Jan. 11th.—Edinburgh Branch : 25, Charlotte Square, Edinburgh, "Aspects of Fire Prevention," Senior Company Officer Dunn, 7 p.m.——Manchester Branch : Engineers' Club, Albert Square, Manchester, "Pulverised Coal Firing for Lancashire Boilers," V. Taylor, 7.15 p.m.

Wed., Jan. 12th.—E. Midlands Branch : Adult Education Centre, Shakespeare Street, Nottingham, "Gas Turbines Applied to Traction Vehicles," P. A. Phillips, 7 p.m.—— Leicester Branch : College of Art and Technology, The Newarkes, Leicester, "Fans and Air Conditioning and Axial-Flow Fans," R. H. Holbeche, 6.30 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Thurs., Jan. 13th.—Southampton Section : Technical College, St. Mary's Street, Southampton, "Production of Pig Iron at Renishaw Works," "Steel," and "Magic in Metal," Films, 7.30 p.m.——Beds and Herts Section : W. H. Allen, Sons and Co., Ltd., Bedford, "Production of Castings for Diesel Engines," C. V. Van der Ben and Mr. Maynes, 7.30 p.m.

INSTITUTE OF FUEL

Thurs., Jan. 13th.—Institution of Civil Engineers, Great George Street, London, S.W.1, "Integration in the Iron and Steel Industry," W. F. Cartwright, 5.30 p.m.

INSTITUTE OF MARINE ENGINEERS

Mon., Jan. 17th.—Student Lecture : 85, Minories, London, E.C.3, "Deck Machinery," W. H. Booth, 6.30 p.m.

INSTITUTE OF PETROLEUM

Wed., Jan. 12th.—26, Portland Place, London, W.1, "Insurance in the Oil Industry," A. T. Wright, 5.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Mon., Jan. 10th.—Scottish Centre : North British Station Hotel, Edinburgh, "Vehicle Suspension," A. B. Sykes and J. Clifford, 7.30 p.m.——N.W. Centre : Engineers' Club, Albert Square, Manchester, "Development and Testing of Brake Lining Materials," 7.30 p.m.——Western Centre : Grand Hotel, Bristol, "Carburation," L. J. Spencer, 7.30 p.m.

Tues., Jan. 11th.—Midlands Centre : Crown Inn, Broad Street, Birmingham, "The Application of Rubber Bonding to Commercial Vehicles," A. J. Hirst, 7.30 p.m.

Wed., Jan. 12th.—E. Midlands Centre : Mechanics' Institute, Nottingham, "Brains Trust," 7.30 p.m.

Thurs., Jan. 13th.—S. Wales Group : S. Wales Institute of Engineers, Park Place, Cardiff, "Skid Resisting Properties of Roads and Tyres," F. H. Kidd, 7 p.m.

INSTITUTE OF WELDING

Tues., Jan. 11th.—Liverpool Branch : College of Technology, Byrom Street, Liverpool, "Welding at the Atomic Plants," L. Rotherham, 7.15 p.m.

Wed., Jan. 12th.—East of Scotland Branch : Chamber of Commerce, Charlotte Square, Edinburgh, "Some Factors Affecting the Costs of Welding," W. Waller, 7 p.m.

Fri., Jan. 14th.—East of Scotland Branch : Technical College Dundee, "Some Factors Affecting the Costs of Welding," W. Waller, 7 p.m.

INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS

Tues., Jan. 11th.—Institution of Electrical Engineers, Savoy Place, London, W.C.2, "British Tractors in the U.S.A.," A. T. Gilling, 2.15 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Jan. 11th.—Airport Meeting : Great George Street, Westminster, London, S.W.1, "The Requirements of a Civil Airport as Typified by London Airport," B. E. Willett, 5.30 p.m.

Thurs., Jan. 13th.—N.W. Association : Engineers' Club, Albert Square, Manchester, "The Construction of the Haslingden and Walmersley Section of the Haweswater Aqueduct," A. S. Bertlin, 6.30 p.m.——Midlands Association : James Watt Memorial Institute, Great Charles Street, Birmingham, "Long-Span Steel Bridges," O. A. Kerensky, 6 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., Jan. 10th.—Informal Meeting : Savoy Place, London, W.C.2, Discussion on "Atmospheric Pollution," opened by G. R. Peterson, 5.30 p.m.

Wed., Jan. 12th.—Radio Section : Savoy Place, London, W.C.2, "Thermionic Valves of Improved Quality for Government and Industrial Purposes," E. G. Rowe, P. Welch and W. W. Wright, 5.30 p.m.——N. Scotland Sub-Centre : Caledonian Hotel, Aberdeen, "Distortions and Transitions in the Atomic Nucleus," Charles Strachan, 7.30 p.m.

Thurs., Jan. 13th.—N. Scotland Sub-Centre : University College, Dundee, "Distortions and Transitions in the Atomic Nucleus," Charles Strachan, 7 p.m.

INSTITUTION OF ENGINEERS-IN-CHARGE

Wed., Jan. 12th.—St. Bride Institute, Bride Lane, London, E.C.4, Exhibition of Films on "The Science of Industrial Water Treatment," J. W. S. Fawcett, 6.30 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., Jan. 11th.—39, Elmbank Crescent, Glasgow, "Experiences in the Stabilisation of Ships," Sir William Wallace, 7.30 p.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS

Wed., Jan. 12th.—General Meeting : Institution of Mechanical Engineers, 1, Birdcage Walk, London, S.W.1, "Recent Trends in Electric Locomotives," G. V. Davy, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Jan. 7th.—General Meeting : 1, Birdcage Walk, Westminster, London, S.W.1, "Impact Torsion Experiments," and "Experiments on the Effect of Rate of Testing on the Criterion of Failure of Certain Mild Steels," N. G. Calvert, 5.30 p.m.

Mon., Jan. 10th.—N.E. Branch : Literary and Philosophical Society, Westgate Road, Newcastle upon Tyne, Annual General Meeting, "Recent Studies of Metallic Friction," F. P. Bowden, 6 p.m.

Tues., Jan. 11th.—Automobile Division : 1, Birdcage Walk, Westminster, London, S.W.1, Conference on Vehicle and Road Lighting : "Rear Lights and Reflectors," K. N. Chandler, K. J. Jones and J. A. Reid ; "Street Lighting Performance," H. R. Ruff and G. K. Lambert ; "Design and Use of Headlamp Meeting Beams," J. H. Nelson ; "Performance of Headlamp Meeting Beams," A. Grime, 10 a.m., 2.30 p.m. and 5.30 p.m.——Eastern Branch : Town Hall, Luton, Annual General Meeting, "Recent Studies of Metallic Friction," F. P. Bowden, 7.30 p.m.——N.E. Branch : Cleveland Scientific Institute, Middlesbrough, "Recent Studies in Metallic Friction," F. P. Bowden, 7.30 p.m.——N.E. Branch : Cleveland Scientific Institute, Middlesbrough, "Recent Studies in Metallic Friction," F. P. Bowden (Presented by Dr. Minter), 6.30 p.m.——S. Wales Branch : Mackworth Hotel, Swansea, Annual General Meeting, 6 p.m.

Wed., Jan. 12th.—E. Midlands Branch : College of Technology, Leicester, "Recent Studies of Metallic Friction," F. P. Bowden, 6.30 p.m.——Southern Branch : Institute of Education, The University, Southampton, "The Mechanical Aspects of Aircraft Generation Equipment," W. R. Hinton, 6.30 p.m.—— Southern Branch : Medway College of Technology, Maidstone Road, Chatham, Kent, "Main Propulsion Gas Turbine Set for the Oil Tanker, 'Auris,'" B.E.G. Forsling, 7.30 p.m.

Thurs., Jan. 13th.—Group Discussion : 1, Birdcage Walk, Westminster, London, S.W.1, "The Use and Misuse of Horizontal Borers," 6.45 p.m.——Scottish Branch : Royal Technical College, Glasgow, "Cutting Tool Research in the U.S.A.," Alex W. J. Chisholm, 7.30 p.m.

Fri., Jan. 14th.—1, Birdcage Walk, Westminster, London, S.W.1, James Clayton Lecture, "The Theory of Plasticity : Recent Achievements and Future Problems," William Prager, 5.30 p.m. ——Scottish Branch : North British Hotel, Princes Street, Edinburgh, "Cutting Tool Research in the U.S.A.," Alex W. J. Chisholm, 7.30 p.m.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Tues., Jan. 11th.—Ordinary Meeting : Institution of Electrical Engineers, Savoy Place, London, W.C.2, "Electronic Switching and Common Control in Auto Exchanges," T. H. Flowers, 5 p.m.

INSTITUTION OF SANITARY ENGINEERS

Tues., Jan. 11th.—Caxton Hall, Caxton Street, Westminster, London, S.W.1, Presidential Induction and Address, 6 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

To-day, Jan. 7th.—Lancashire and Cheshire Branch : College of Technology, Manchester, "The Present Situation on Retaining Wall Design," P. W. Rowe, 6.30 p.m.——Western Counties Branch : University of Bristol Geology Lecture Theatre, Bristol, "Recent Bridge Works in Bristol District," H. G. Lakeman, 6 p.m.

Tues., Jan. 11th.—Lancashire and Cheshire Branch : College of Technology, Liverpool, "Welding at the Atomic Plants," L. Rotherham, 7 p.m.

Thurs., Jan. 13th.—11, Upper Belgrave Street, London, S.W.1, "Gasholder Development and Design," W. R. Garrett, 6 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Jan. 7th.—Pepys House, 14, Rochester Row, London, S.W.1, Film Evening, 7.30 p.m.

Fri., Jan. 14th.—Ordinary Meeting : Pepys House, 14, Rochester Row, London, S.W.1, "An Assembly Line and Materials Handling Technique in the Production of Heavy Vehicles," W. J. Kease, 7 p.m.

LIVERPOOL ENGINEERING SOCIETY

Wed., Jan. 12th.—24, Dale Street, Liverpool, "A General Survey of Helicopters with Emphasis on Engineering Design," J. S. Shapiro, 6 p.m.

LIVERPOOL METALLURGICAL SOCIETY

Thurs., Jan. 13th.—Liverpool Engineering Society, 24, Dale Street, Liverpool, Open Discussion on "Inspection versus Production," 7 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS

To-day, Jan. 7th.—Engineers' Club, Albert Square, Manchester, "Engineering Practice in the Gas Industry," T. Andrews, 6.45 p.m.

NEWCOMEN SOCIETY

Wed., Jan. 12th.—Ordinary Meeting : Iron and Steel Institute, 4, Grosvenor Gardens, London, S.W.1, "The Taylors of Southampton : Their Ships' Blocks, Circular Saw and Ships' Pumps," The Late H. W. Dickinson, 5.30 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Fri., Jan. 14th.—Mining Institute, Newcastle upon Tyne, "Gas Turbine Combustion Systems," I. G. Bowen and W. Tipler, 6.15 p.m.

SOCIETY OF INDUSTRIAL ENGINEERS

Fri., Jan. 14th.—The George Hotel, Church Lane, London, N.W.9, "What is Your Problem ?" General Discussion, 7 p.m.